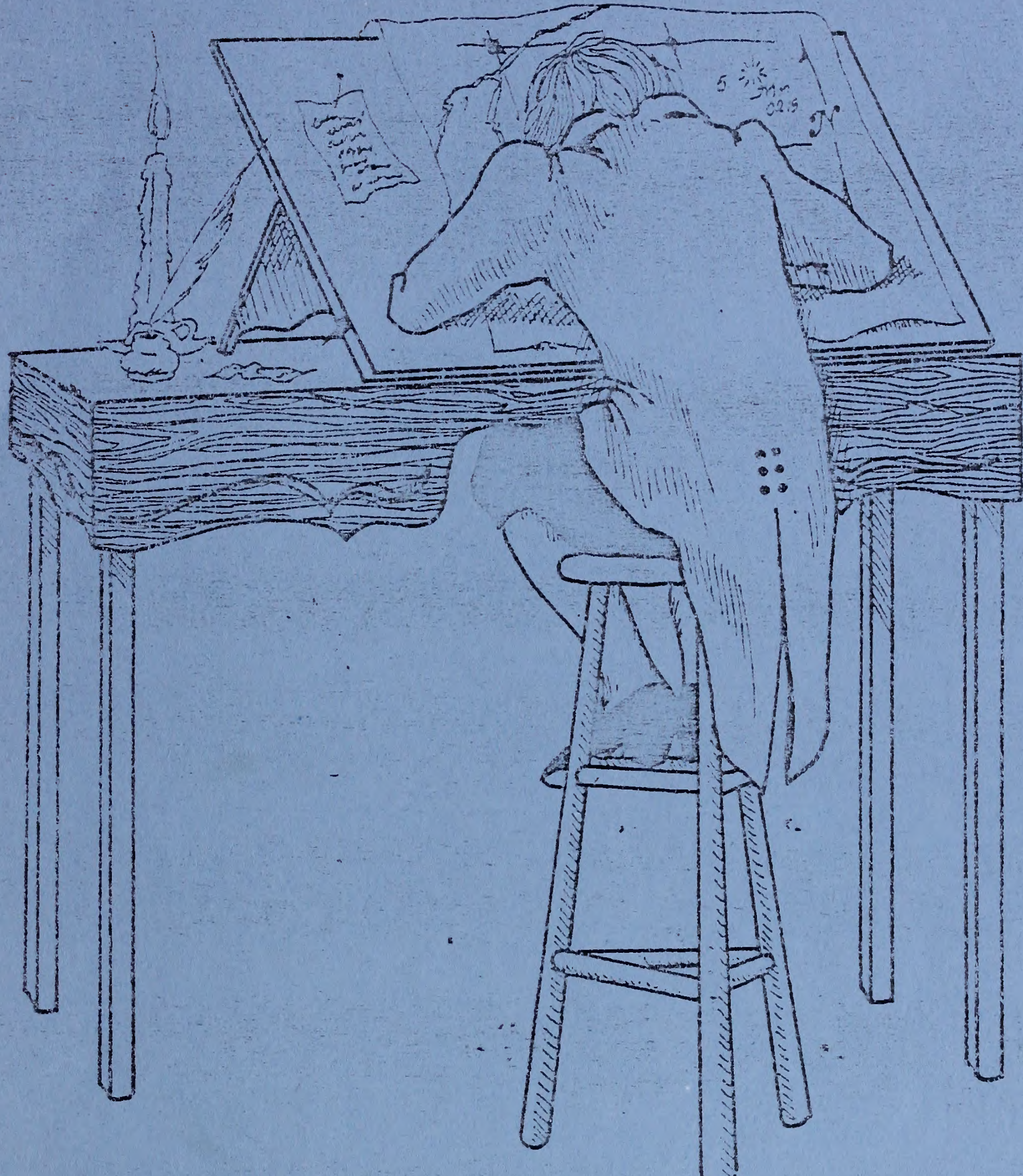

Interactive Computer Graphics
FINAL REPORT

December 1976

INDEX

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
DENVER SERVICE CENTER
DENVER FEDERAL CENTER. BUILDING 50
DENVER. COLORADO 80225

To: Director 400 December 25, 1976

From: Director, DSC

Subject: Interactive Computer Graphics Team Report

The following report is submitted in accordance with WO IM 76-415 and completes WAR, same subject unnumbered, approved 10/13/76.

I believe the analysis and summaries and recommendations contained in the report are sound. A thorough review should be made of this report as it relates to the Bureau's mission and to the Strategic Plan for Information Management. The Recommendations are far-reaching and the full impact of this space age technique is not well understood.

The Recommendations charter a course for the Bureau which will not only test the Strategic Plan to some extent, but give us a preview of the future. I strongly suggest a detailed presentation on the subject be given with an informal question and answer period so there is no misunderstanding of the destination and goals if this advice is followed.

Richard L. Thompson

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
DENVER SERVICE CENTER
DENVER FEDERAL CENTER, BUILDING 50
DENVER, COLORADO 80225

To: Director, Denver Service Center December 10, 1976

From: Interactive Computer Graphics Team

Subject: Final Report and Recommendations

Attached is the final report, including suggested directions for the Bureau from the Interactive Computer Graphics Team.

The Team has reviewed many volumns of data about other systems, studied BLM efforts, and tried to Refine the requirements into a set of specifications.

In our recommendations we have also attempted to give the Bureau some direction and advice as it approaches this new era in Information Management. It has been a difficult task, primarily due to the absence of definitive information on the subject and the lack of experience by our resource technicians, who have to define their grapic needs.

The team extends an offer of support for any further information, presentation or involvement in this matter.

We would like to express our thanks to members of your staff who assisted the team both in supplying data and in giving clerical and logistical support.

Merry Christmas

Eugene D. Russell
Eugene D. Russell
Systems Coordinator
Graphics Team Leader
Denver Service Center

David H. Nelson
David Nelson
Team Leader
Resource Information Systems Development Team
Oregon State Office

Dierk Rhynsburger
Computer Systems Analyst
Alaska State Office

Jerry Ives
Training Leader
Denver Service Center

James May
Jim May
Computer Specialist
Denver Service Center

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

United States Department of the Interior

[illegible]

To: Director, Denver Service Center December 10, 1979

From: Interactive Computer Graphics Team

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We would like to extend our thanks to members of your staff who assisted the team [illegible] and [illegible] report.

[illegible]
Denver Service Center

[illegible]
[illegible] Team
Denver Service Center

[illegible]
Colorado State Office

[illegible]
Denver Service Center

[illegible]
State Office

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
WASHINGTON, D.C. 20240

D-100 I
D-110
D-120
D-140
D-150 A
D-200 A
D-300
D-400
D-500
D-600 I
D-700
D-800
UB I
INFO
OFC
RF I
BIND. I

August 5, 1976

Instruction Memorandum No. 76-415
Expires 6/30/77

To: SCD, SD - Oregon and Alaska

From: Associate Director

Subject: Interactive Graphics Core Team Assignment

The Steering Committee has recommended that a standard graphics and digitizing systems capability be developed within the Bureau. The first phase of this project will be to define requirements, establish criteria and develop specifications for this effort, as indicated in the enclosures. To accomplish this, a Technical Interactive Graphics Team will be formed. Arrangements have been made with the respective Directors for assignment of personnel to the team as follows:

Eugene Russell	- Team Leader (DSC)
Dan Hegarty	- Data Processing (DSC)
Allen Arnold	- Mapping (DSC)
Dave Nelson	- S.O. Resources (Oregon)
Dirk Rhynsburger	- Data Processing (Alaska)

The first team meeting will be held on August 19, 1976, at 8:30 A.M., in Room 1116 of the Service Center, at which time the scope of effort will be defined and project scheduling will be developed.

In light of this project, the suspension on further development of CRIS, ORIS, and Alaska interactive graphics will remain in effect.

George L. Turcott

Enclosure 1
Encl. 1 - Interactive Graphics Core Team

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

Interactive Graphics Team

1. Objective

The Interactive Graphics Team will prepare recommendations, criteria and specifications for an automated capability for mapping, graphics and digitizing. The team will also serve as an advisory group to Resource DRD teams and may be assigned system design and development responsibility.

2. Approach

The Interactive Graphics Team will meet with representatives of the Steering Committee, AD-Technical Services staff, Denver Service Center ~~staff and personnel presently working on CRIS, ORIS and the Alaska graphics~~ system.

These meetings will provide an opportunity for the team members to work together in identifying the scope of the project. The following are some discussion points:

1. Establishment of work relationships among team members and assignment of specific responsibilities.

2. Definition of the areas of work involved. This includes identification of BLM needs in graphics and digitizing, evaluation of existing systems and identification of new systems needed.

3. Determination as to the best method of accomplishing the objectives. This includes decisions concerning most effective use of personnel resources, methods of scheduling and control of the project through the use of reporting procedures and milestones, location of personnel, use of contracting, evaluation of available software, etc.

4. Definition of the specific work tasks involved, including estimates of manpower and time required for completion. These tasks will include systems design, programming, testing and implementation of graphic computer systems.

Once established, the Interactive Graphics Team will be responsible for all phases of the project, subject to review and approval by the Steering Committee. The team may request short term use of BLM personnel with other technical skills for either advice or for execution of specific sub-tasks. All efforts towards system development will be in accordance with the implementation of the strategic plan.

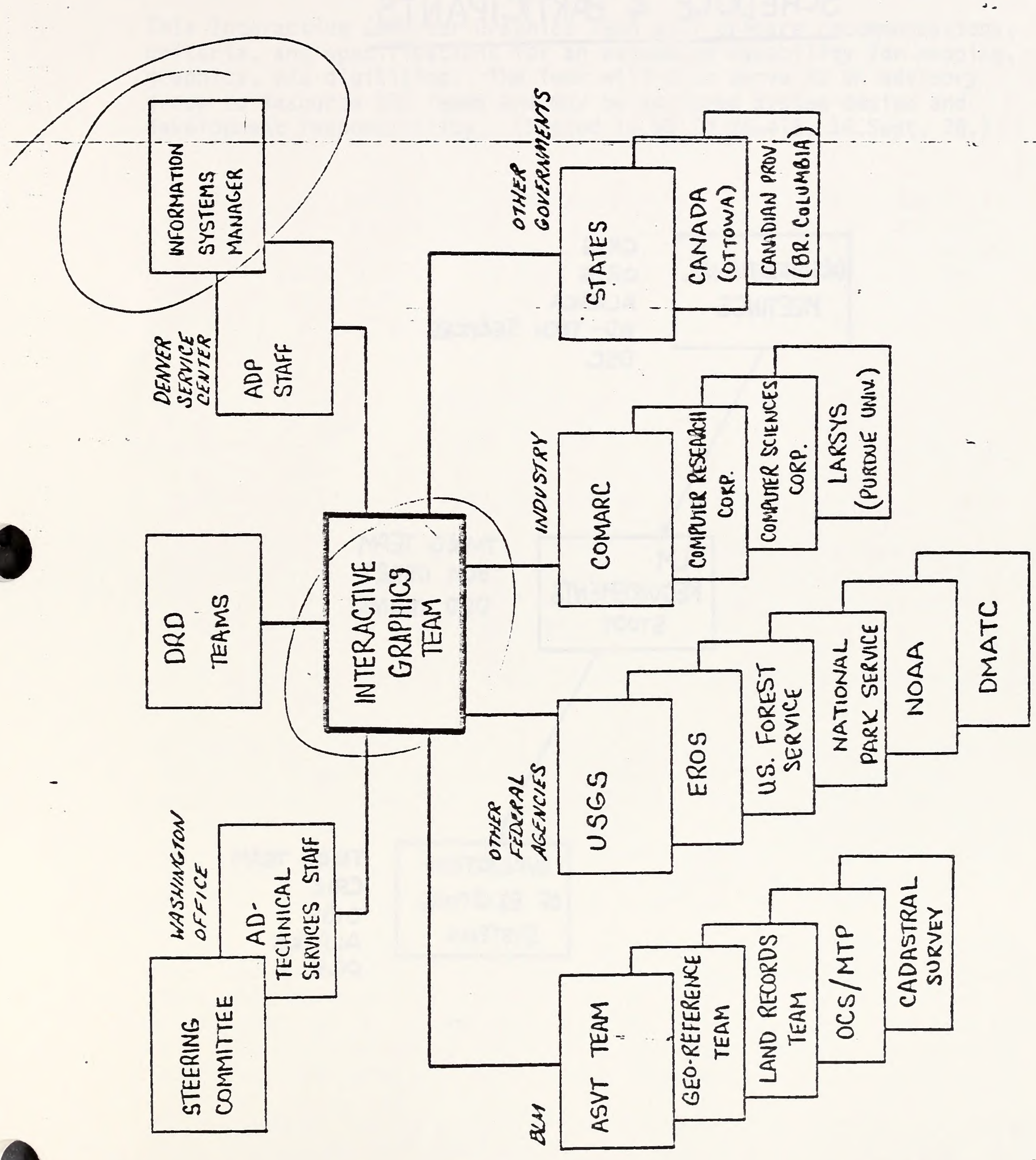
3. Coordination

Close contact must be maintained with other components within BLM,

Encl 1-1

other federal agencies, other governments and industry sources. These relationships are shown on the accompanying chart. Liaison with these groups will help eliminate duplicate effort in the collection of data and the development of processing systems. It will also insure compatibility among data being collected and stored and provide proper interface between systems where applicable. Specific emphasis should be placed upon the relationship with the Resource Inventory DRD Team since this project will provide direct support for their effort.

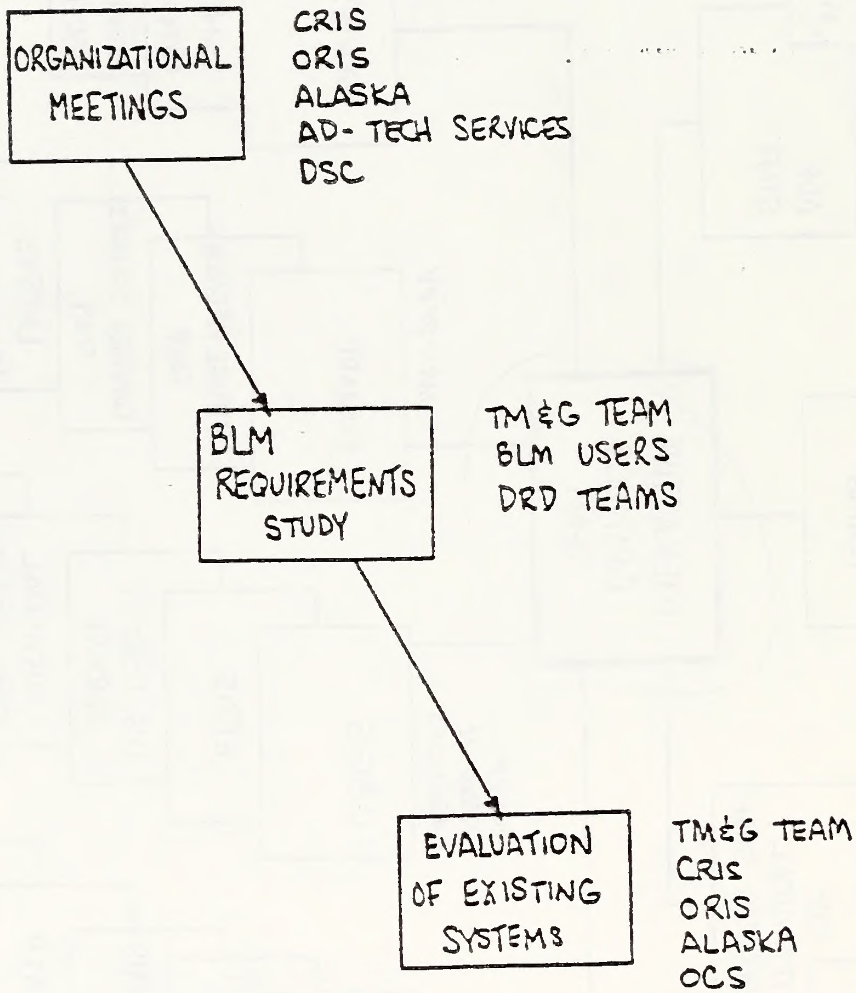
Encl 1



STEERING COMMITTEE
WASHINGTON OFFICE
AD-TECHNICAL SERVICES STAFF
DRD TEAMS
DENVER SERVICE CENTER
ADP STAFF
INFORMATION SYSTEMS MANAGER
INTERACTIVE GRAPHICS TEAM
BLM
ASVT TEAM
GEO-REFERENCE TEAM
LAND RECORDS TEAM
OCS/MTP
CADASTRAL SURVEY
OTHER FEDERAL AGENCIES
USGS
EROS
U.S. FOREST SERVICE
NATIONAL PARK SERVICE
NOAA
DMATC
INDUSTRY
COMARC
COMPUTER RESEARCH CORP.
COMPUTER SCIENCES CORP.
LARSYS (PURDUE UNIV.)
OTHER GOVERNMENTS
STATES
CANADA (OTTOWA)
CANADIAN PROV. (BR. COLUMBIA)

Encl 1-3

SCHEDULE & PARTICIPANTS



Encl 1-4

<u>OBJECTIVES</u>

This Interactive Computer Graphics Team will prepare recommendations, criteria, and specifications for an automated capability for mapping, graphics, and digitizing. The Team will also serve as an advisory group to Resource DRD Teams and may be assigned system design and development responsibility. (Stated in WO IM 76-415, 14 Sept. 76.)

INTERACTIVE COMPUTER GRAPHICS BACKGROUND

Although Interactive Computer Graphics is a relatively new field the Bureau has been involved, to some extent, in this process for the last decade. Probably the first effort was in Eugene, Oregon on the Map Model system. There have been major revisions to the original system both in software and hardware and name. This system now called ORIS (Oregon Resource Information System) is currently operational on the Siluslaw Resource Area, Eugene Oregon District.

Second to get underway was the Denver-based CRIS (Comprehensive Resource Information System). This system primarily got its emphasis during the energy crisis and was used on the Decker-Birney Planning Unit in Montana. This area has management jurisdiction over some valuable coal fields and CRIS was used in conjunction with this resource. Due to problems, to be discussed later, this effort has been shelved.

Next the AGIS (Alaska Geographic Information System) was created. This was in support of the massive land claims in Alaska brought about by ANCSA, (PL 92-203.) This system has been developed around the land title, description and case management workload. It is operational today and serving a needed purpose.

Last, "OASIS" is being tested in the area of Outer Continental Shelf activity. This system is being developed under contract by Computer Sciences Corporation and will eventually encompass all records dealing with the management of the OCS.

This system is currently under development and due to be demonstrated late this year.

Recently (within the last two years) the Bureau attempted to review the first three of these systems to determine if: a) There was duplication, b) they could be merged into one, c) or pick the best. These efforts generally failed due to: a) No clear, concise set of Bureau requirements to match each system against, b) extremely technical processes being evaluated by "management" and c) the purposes being so different that it was hard to relate one to the other.

During this same time frame the Strategic Plan for Information Management was formulated and the decision was made to embark on the course this plan advised. With this decision a halt was called to further development on any of the three systems just described. The main reason for this decision was to create a standard BLM graphics procedure in support of the Strategic Plan rather than many fragmented efforts.

OCS management couldn't wait on the Strategic Plan so they contracted with the company mentioned earlier, to provide a computer system to assist in the management of this valuable resource.

In August 1976 the interactive graphics team was created to take a look at these graphic systems and give some guidance to BLM in this little understood area.

Some negative observations can be made about previous efforts:

a) All are generally single purpose in their use, not multi-purpose.
b) All were understaffed.
c) Specific written requirements were lacking at the beginning of all.
d) None had adequate equipment.

On the positive side:

a) Each fulfilled or are fulfilling a purpose.
b) Many mistakes were made in this development but from this has emerged a small cadre of experienced, extremely bright personnel who have the ability to provide BLM with as good a system as there is in operation anywhere today.
c) We have profited in having different types of equipment. We now know some types of equipment to avoid.
d) We have gained some experience in:
   1) Data collection
   2) Communications
   3) Desirable menus
   4) Program size
   5) Data base size
   6) Contracting
   7) Different vendor equipment interface
   8) Maps
   9) Data correction
   10) Our customers

Other agencies have failed after huge expenditures of manpower and money due to:

1. Lack of user involvement
2. Lack of training
3. Lack of proper equipment
4. Lack of concept conditioning and management support.

We believe that because of the experiments which have been made in BLM, the close coordination and cooperation of these units and the support of management we will be able to succeed where others have failed. Most encouraging is the enthusiasm of the field personnel involved in the Resource DRD effort.

PROJECT APPROACH

The Team attempted to use a simple, logical approach to this study. The first information needed was the availability of data for Graphics. How many maps, what kind of condition are they in and what information is available from sources external to the Bureau.

Second, how is the best, most economical and easiest way to capture this data and put it in an automated system.

Third, how can it be processed, stored and moved from collection point to storage and from storage to use.

Fourth, who, where are the users and what do they need to get the job done.

Having defined these basic categories as the area in which the Team was to work, a plan was devised and implemented to collect the information, analyze it, and produce the report which follows:

To collect information on maps, overlays, etc., an assignment was given to the Office of Special Mapping DSC. They sampled three PD states and prepared a report based on their findings. (See Appendix) The representatives from Alaska and Oregon furnished information on these unique states.

State of the ART information on digitizing, scanning and any other means of entering Geographic was obtained from a report prepared by Scientific Systems Development. (See Appendix)

The processing, storage and general handling of the information was a task requiring all member participation. Other agencies were visited and a great amount of documentation was reviewed along with detailed review of BLM graphic efforts to date. The Team also combined their efforts in defining the user community, their needs and from this prepared a set of specifications for a graphic system.

This information was then analyzed by the Team and the recommendations were prepared for this report.

Summary and Recommendations
General

The interactive computer graphics problem in BLM is a tough one. We need this ability to support the Strategic Plan but problems are endless. Some of the major ones are:

1. Poor map base
2. Overlay information not standard
3. Manual digitizing extremely slow
4. No major breakthrough in the data collection/entry problem
5. Very scarce ADP skills in this area
6. Little or no equipment presently available in BLM to develop this process on
7. Not well defined, interface with data from other agencies
8. Little ability or understanding of the majority of BLM people in this area
9. A data requirement which is staggering possibly 100 billion characters
10. A fully utilized work force with little slack time to spend on this subject

This paints a very bleak picture. Maybe it is brighter than it appears. The recommendations of this report are in a positive vein. Let us do some experimenting and get better information on the subject. As we are doing this, there is a good prospect that innovations and breakthroughs will come. There are some very encouraging signs. We have some very bright field professionals who feel it <u>must</u> work. This desire coupled with a dedicated ADP force may accomplish what now seems impossible.

Data on costs, production and effective utilization of this process are not available as they relate to BLM's information. The recommendations are to conduct some very controlled testing and using the results make decisions which will set the Bureau's course.

A. MAPPING

SUMMARY:

We have divided mapping into four categories: base maps, planning unit maps, URA overlays, special use maps, and project maps.

The current Bureau policy, with respect to base maps, is that we will use USGS maps. Although there are some states using BLM produced base maps, these maps are being phased out. All Bureau lands will have coverage by the end of 1977 with large scale USGS mapping. (See Issue paper "A Geo-reference System for the Bureau Information System") These will be 1:24,000 (7-1/2"), 1:62,250 (15' in the conterminous states), and 1:63,360 (15' in Alaska) topographic maps; or 1:62,250 orthophoto quads.

The 1:100,000 intermediate scale map is being produced thru cooperative agreement. The Bureau, consequently, has significant impact on priority settings.

At the smaller scale of 1:250,000, we have complete coverage. This is the old AMS series which the GS has taken over. Many of these maps will not meet national map accuracy standards. The GS through revision, is correcting this.

Only a minimal amount of information contained on these maps is digitized. Of the digitized information, the majority descibes the land form. The AMS has digitized the land form on most of the 1:250,000's. The GS, as an output from the process of producing orthophoto quads produces a digital terrain profile.

For future 1:24,000 maps, the GS will use an additional number scribed bases containing unique features, thus increasing the cost effectiveness of digitizing base map data. The 1:100,000 mapping process had been designed with future digitizing in mind.

The GS map and the aerial photograph are usually the basic document for the storage of information. The resource specialist, while in the field, often records his observations on GS maps or the aerial photograph.

We define Planning Unit maps as being those maps which are used as a base for the URA overlays. These maps are usually Bureau produced: 1" = 1 mile, or 1/2" = 1 mile planametric maps. Although, at times, GS maps are used. The Bureau produced maps are usually of low quality, do not meet national map accuracy standards, and do not contain geographic reference information. Because of the lack of meeting standards and not containing reference information, it will be extremely difficult to accurately position linear features and area boundaries portrayed on the URA overlays.

There are around 20,000 URA overlays. The information is not located to map accuracy standards, but includes alphanumeric and symbolic information, and often includes more than one feature. Consequently, the digitizing of the data will require significant human involvement.

Special use maps are unique to a specific resource activity or office. They are in many different scales and contain various types of information. Most will probably have to be hand digitized.

Project maps are high quality and large scale, (i.e., a recreation site map.)

RECOMMENDATIONS:

Provide the office of Special Mapping, DSC, with an automated cartographic system. This can be offline. This is necessary to meet the requirements of Chapter 3 of DM 757, the Cooperative Agreement with the GS on intermediate scale mapping, and to digitize map information as it's produced, not at some later time at increased cost.

Begin digitizing for basic reference information the drainage, major transportation, land grid, and significant man-made features information from the 1:100,000 map scrib plates. With respect to the URA overlays, we recommend going to the source document from which the URA information was obtained to obtain the basic data.

The decision to enter information on special maps and project maps will have to be handled on a case-by-case basis.

Since most of resource management decisions are affected by topography, the system must have some way of portraying topography. Therefore, we recommend work begin on the development of a terrain model.

B. DIGITIZING

SUMMARY:

There is a wide variety of digitizing equipment available on the market, ranging from components such as boards, paper tape and magnetic tape data recorders, storage CRT graphic displays, minicomputers, disk memories, printers, keyboards, TV cameras, film scanners, microdensitometers, etc. to systems composed of these components together with software for geometrical manipulation and data film storage, editing and retrieval.

There is no system that automatically does the entire graphic digitizing job. This ideal system would consist of a hopper at one end which would accept BLM quad maps, USGS 7-1/2 minute quads (1:24,000) and 1 degree by 30 minute (1:100,000) maps, planning unit overlays, Master title plats, survey plats, historical indices, etc. and a high data rate channel to a megascale digital computer having the BLM data base stored in its terabit random access store.

BLM graphic data is recorded on maps of differing scales, using a variety of line widths and a range of quality. Data associated with graphics are available as alphanumeric characters, e.g., UTM, state plane, or latitude/longitude coordinates, area surface and subsurface ownership categories. There is no one best system for digitizing this variety of input data forms.

A large amount of data awaits to be digitized in each of a variety of formats. Consideration should be given to using the best digitizing system for each class of data rather than attempting to use a single system for all classes of data. For instance, a key entry system appears well suited for gathering alpha-numeric data in existing BLM manual data files, a digitizing board appears suited for the digitizing of rectangular ownership lots and survey corners, and a line follower system appears well-suited for non-analytical curvilinear graphic data such as surface hydrography, soils maps, and resource overlays.

RECOMMENDATION:

If the Bureau's graphic system is going to embrace its almost limitless sources of natural resources and land use information within a viable time period it must develop a digitizing system (this includes hardware, software, manpower, and operating procedures) capable not only of an initial high rate of production but also the ability to incorporate better methods and technologies as they become feasible.

Digitizing will be one of the most costly efforts in the Strategic Plan and specifically graphics.

The Bureau should consider testing a graphic data input section much like we know keypunch today.

Small processor (mini) could support several digitizers which would be operated in an on-line graphic display fashion. It seems this is the most practical way to start. Very precise instructions would have to be issued to the field prior to their sending maps or overlays in to be recorded. This would also inforce the standards set up in the mapping section. As maps were digitized, the original document would be sent back to the field and the entry group would enter the new information into the main computer storage.

In conjunction with this effort, all available automated coordinate data should be used, e.g., USGS, Army Map Service, NOBA, etc. Also at the same time, tests can be run and documentation recorded on the Alaska scanner which will be used in Land Status Recordation.

At the end of a year, or some predetermined time, the results of all efforts could be evaluated and a new course set.

C. USERS

SUMMARY:

Potential users of the Bureau's system consists of:

BLM - 80 percent of area and district people are assumed to be prospective users of a BLM computerized information system.

OTHER FEDERAL AGENCIES - Interfaces with needs of USGS, USFS, Park Service, EPA, etc.

NON-FEDERAL - Other government (state, county, City, etc.)

NON-GOVERNMENT - 1) corporate, commercial
2) non-commercial, citizens

Characteristically the user audience of this graphic system addresses have not worked in an environment in which interactive computer processing is an integral part.

The implementation of an interactive graphics capability will require a drastic change in thinking and operational procedures within our field units. It is hard to visualize today how they will function in a computer graphic environment, but certain things we can project. Due to the comlexity of our natural environment resource managers are faced with the seemingly insurmoutable problem of combining or relating the various environmental factors into a logical construct. Until recently this function was performed by the laborous process of overlaying resource maps plotted on mylar and tracing the resultant. However, today it has become apparent that this methodology is too slow and inaccurate to keep pace with the accelerating demand upon our natural resources. The graphic system will perform these tasks rapidly and accurately providing the user with an almost limitless spectrum of resource information and relational constructs. Updating will be simple and most recalculation will be automatic. Data resolution can be varied as the need dictates. Erroroneous or out-of-date data can be more easily located and corrected or deleted. Service to the public will be enhanced because of the wide range of information available at many locations. Planning will not resemble the activity we know today due to availability of information, again this function can be performed in many locations not available to us today.

RECOMMENDATION:

We must make the user an integral part of the overall system at the earliest possible time. This could be accomplished through user training, management orientation, involving the user and management in the development of the graphic system, investigating impacts on present planning procedures, and incorporating user feedback as an integral part of system development and implementation. This will nurture the operational condition in which the user views the system and data base as theirs. BLM must begin today to train and prepare the BLM Resource people so that the impact of this new concept will be lessened to a great extent. BLM has a good training facility, so lets put them to work in this direction.

D. BLM GRAPHIC CAPABILITIES

SUMMARY:

In aggregate the Bureau's four graphic systems (ORIS, CRIS, AEGIS, OASIS) represent not only the end product of extensive research, development, trial and error but also the state of the art in graphic map processing. We do not have to go outside the bureau for this expertise.

(See Minimum Design Criteria Section in the Appendix)

RECOMMENDATIONS:

Any further development of graphics be on the integrated bureau system as defined under the Strategic Plan.

(See "E" for further recommendations)

Further development, when aimed at a common goal, should be encouraged. The moratorium on systems development should be lifted and progress continued as manpower is available.

Technicians should be brought together as frequently as travel permits to exchange ideas and benefit from each other's work.

E. SHORT RANGE RECOMMENDATIONS

It appears, at this time, that the DSC computer acquisition and installation will be delayed probably at least six months. This means that nearly a year from the time this report is due, is the earliest time we can count on any effective computer support from DSC. With the work on Phase I of the Strategic Plan continuing and a high percentage of this data being graphic it would seem to be an error not to take advantage of the delay and experiment and test as much as possible. Then, when equipment is available, there should be less errors and false starts. Can this be done?

Here is one suggestion: One half of the Eugene District has some data collected on seven different features and has a graphic system in daily operation today. BLM could finish collecting the data for the rest of the district along the lines of the DRD requirements. This could be accomplished by setting up a small data collection unit with digitizing and other input media. Factual information on data collection costs and time could be collected.

For the time period involved this unit would not have to be manned with permanent positions, but could probably be run by temps from the college. This would be a real test of procedures. The data could be processed on the Lane County computer. This system will very nearly parallel the DSC system where there will be a large host computer and either a mini or just dumb terminals at user stations. The Lane County equipment is modern and very reasonable in cost.

To make this recommendation more attractive there is strong, experienced leadership there to head this type of project and a healthy raport with users is already established.

Some tinkering with software would have to be accomplished. This again, would seem to be an opportune time to get the graphic technicians of BLM together and give them direction and support on the best and most efficient way to utilize the equipment and system.

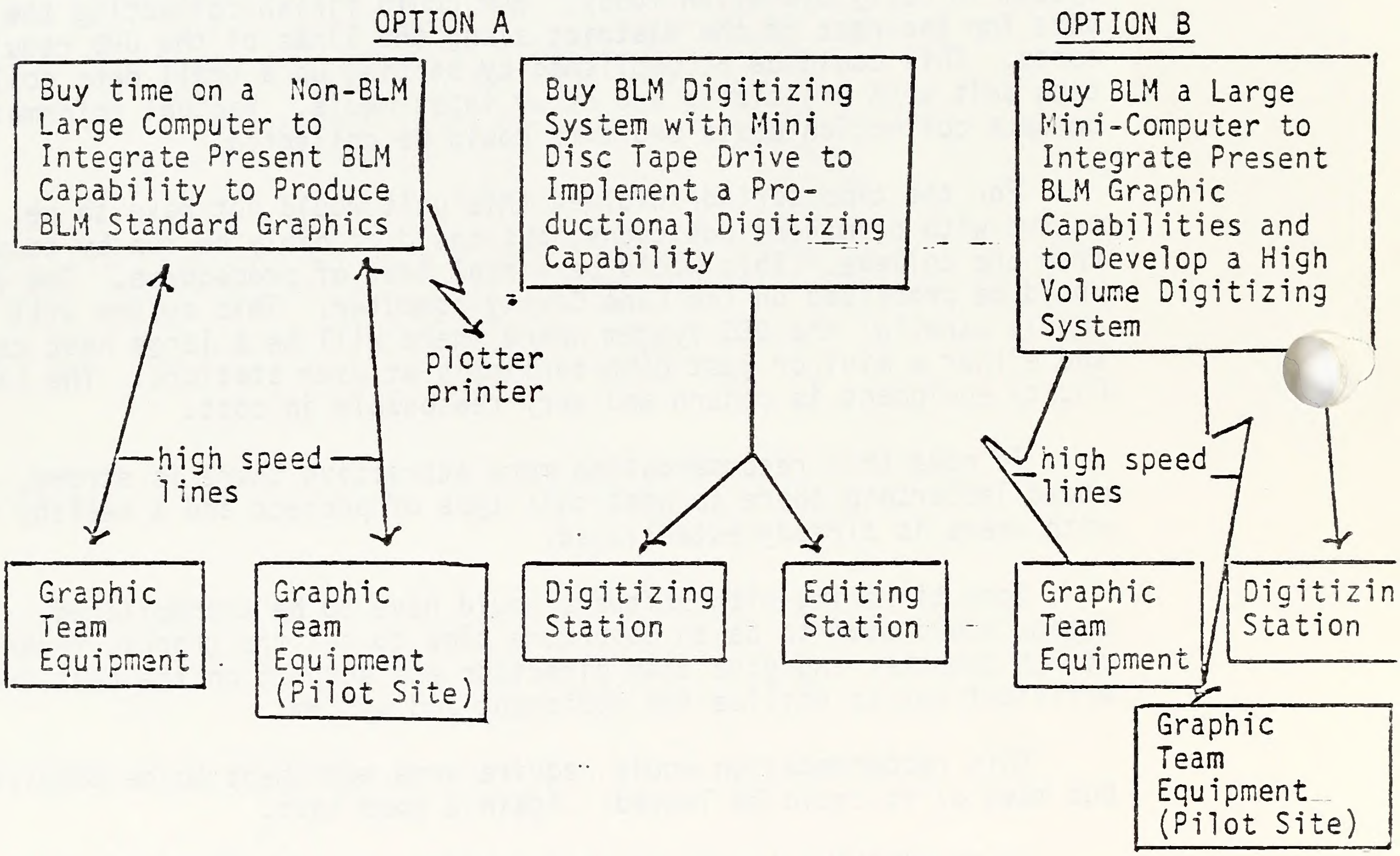
This recommendation would require some equipment to be acquired but most of it could be leased. Again a good test.

As an addition to this test it would seem appropriate to pick a PD District, not necessarily in Oregon, and add them to the test. Possibly the area in Southern Idaho that is used in the ASVT test. Their equipment is similiar to that required by graphics and could be shared.

We should route the shopping list of information system capabilities and requirements for geographic and graphics data handling to select user audiences for appraisal. Integrate user feedback into the BLM graphic system or in related application areas wherever feasible.

The new graphics group invisioned in the above test should consist of a team leader, three to five programmers/analysts, one to two cartographers/digitizer operators, and a map specialist/programmer data base planner/coordinator. Organization should be located at the Denver Service Center but organizationally located independent of Data Processing. The data base planner/coordinator should be brought on board early in the system design phase and provide the user to system interface at the pilot site.

We have outlined below two alternate configurations to meet the short term needs of the graphic system. Both alternatives are based on the premise that to be operational we need an interactive digitizing system to meet temporal and productional requirements for a Bureau system. Option A places the primary processing functions on an independent mainframe, while option B integrates both digitizing and primary processing on a single computer, in this case a mini with sufficient capabilities to handle both functions.



1- Software moved to BLM mainframe at first opportunity
2- Consider the alternatives of deferring the DBMS tie until BLM mainframe and its associated data base management system is available or using the host with the possibility of later converting to the BLM System.
3- To be a viable alternative both processing and digitizing capabilities must be implemented.

Long Range Recommendations:

Based on what we know now, the following course would seem appropriate dependant on the test results.

1. Plan and budget for equipment based on activity/ priority.
2. Collect information intensively on the same basis.
3. Collect information in other areas on a time-personnel available basis.
4. Develop operating standards and enforce them.
5. Embark on an intensive training program.
6. Perform a study on organizational impact of this system.
7. Assemble a graphics development group (technicians) as soon as equipment is known and requirements are defined and approved.
8. Continue to work closely with USGS and USFS and attempt to exchange automated data rather than collecting all our own.
9. As early as possible determine the need and prepare the acquisition for either Regional computers, State level computers on "smart" District capability.
10. Endeavor to make use of remote sensing as an input source.

APPENDIX

BASE MAP DATA

The following matrices show the relationship between the scribed bases and the thirteen base map data categories for the 1:250,000 and larger scale USGS maps. Of the thirteen data categories, the first eleven are defined in the 1975 USGS proposal, "Digital Cartographic Data Base Preliminary Description."

The twelfth and thirteenth are additional data categories which are also of significant interest to the Bureau.

The most significant point that the matrices show is that for the older maps, most bases contain more than one feature. Most of the maps of BLM lands fall into this category. The newer maps, primarily the 1:100,000, are produced from more bases which contain unique features.

The cost of digitizing features on bases increases with the increase in the number of features on a base. This is because more manual processes are required to separate the features.

1: 100,000 USGS/BLM

	PLANAMETRIC																								
	Projection	Roads	Misc. Culture	Civil Boundaries	Land Lines	Lettering	Lettering Land Line	Road Fill	Sand	Intricate Systems	Shifting Sand	Tailings Pond	Moraine, Gravel	Incorporated Area Tint	Drainage	Swamp	Open Water	Inundation	Intermittent	Lettering, Water	Highway Designation	County Perimeter Tint	Public Park or Recreation Area	Forest or Game Land Area Tint	Military or IR Tint
1. Reference System	X					X																			
2. Hypsography																X	X								
3. Hydrography															X	X	X	X	X	X					
4. Surface Cover																									
5. Non-vegitative Features						X			X	X	X	X	X												
6. Boundaries				X		X								X								X	X	X	X
7. Transportation Systems		X				X		X													X				
8. Other Significant Man-made Structures			X			X																			
9. Survey Information			X				X																		
10. Geographic Names					X			X																	
11. Orthophotographic Imagry																									
12. Public Land Survey Grid				X		X	X	X																	
13. Land Status																									

1: 100,000 USGS/BLM

	LAND STATUS																					CONTOUR	
	Natl. Resource Lands	O&C & CBWR Lands	Natl. Forest	Natl. Grasslands	Natl. Parks & Mon.	Indian Lands or Res.	Military Res. and Withdrawls	Wildlife Refuges	L.U. Lands	TVA	State Lands	BOR	Power Withdrawls & Classifications	Fed. Agency Protective Withdrawls	Public Water Reserves	ERDA	O&C Lands Admins. by U.S. Forest Service	Radio & Air Facilities	Misc.	State Wildlife, Park & Outdoor Rec. Areas	Acquired Lands	Contours	Contour Figures
1. Reference System																						X	X
2. Hypsography																							
3. Hydrography																							
4. Surface Cover																							
5. Non-vegitive Features																							
6. Boundaries																							
7. Transportation Systems																							
8. Other Significant Man-Made Structures																							
9. Survey Information																							
10. Geographic Names																							
11. Orthophotographic Imagry																							
12. Public Land Survey Grid																							
13. Land Status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		

USGS 1:24,000 FUTURE (New Starts)

																											REVISIONS				
	Lettering, Black	Culture	Sand	Contour	Contour Numbers	Intricate Surface	Tailings	Moraine, Gravel	Cont. No. Mask	Lava	Drainage	Swamp	Lettering, Blue	Open Water	Inundation	Intermittent	Road Fill	Land Lines	Fence Lines	Urban Area	Boundary	Lettering, Red	Woodland	Orchard	Scrub	Vineyard	Lettering	Line Drawing	Pattern	Open Water	Urban Area
1. Reference System	X										X																				
2. Hypsography				X	X				X			X		X														X			
3. Hydrography	X										X	X		X	X	X											X			X	
4. Surface Cover																							X	X	X	X					
5. Non-vegitative Features	X		X			X	X	X		X																					
6. Boundaries	X																				X							X			
7. Transportation Systems	X	X															X										X	X			
8. Other Significant Man-made Structures	X	X																	X								X	X			
9. Survey Information	X	X																									X	X			
10. Geographic Names	X																										X				
11. Orthophotographic Imagry																															
12. Public Land Survey Grid	X																X	X			X							X			
13. Land Status																															

USGS 1:24,000 / 1:62,500 / 1:63,360 (PAST)

	Culture	Lettering	Contour	Sand/Gravel	Intricate Surface	Drainage	Swamp	Water	Road Fill, Land Lines, Fence Lines	Urban Area	Boundary	Woodland, Orchard, Scrub	REVISIONS: Lettering	REVISIONS: Line Drawing	REVISIONS: Pattern	REVISIONS: Open Water	REVISIONS: Urban Area
1. Reference System	X	X				X											
2. Hypsography			X				X	X						X			
3. Hydrography						X	X	X					X	X		X	
4. Surface Cover		X										X		X			
5. Non Vegitative Features		X		X	X									X			
6. Boundaries		X									X		X	X			
7. Transportation Systems	X	X							X				X	X			
8. Other Significant Man-made Structures	X	X							X				X	X			
9. Survey Information	X	X											X	X			
10. Geographic Names		X											X				
11. Orthophotographic Imagry									X		X						
12. Public Land Survey Grid	X																
13. Land Status																	

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United States Department of the Interior

BUREAU OF LAND MANAGEMENT
DENVER SERVICE CENTER
DENVER FEDERAL CENTER, BUILDING 50
DENVER, COLORADO 80225

Memorandum

To: Team Leader, Interactive Computer Graphic Team

From: Lynn A. Strand, Chief, Branch of Photogrammetry

Subject: Unit Resource Analysis (URA) Overlay Study Report

In response to your memorandum, 1260 (D-100) of August 31, 1976. The information requested in the memorandum is as follows:

Question

2. <u>Some Guidelines on Information Needed for the Study</u>

A. Maps

1. Standard

Answer - The standard maps used by the Bureau for the URA base maps are as follows:

a. BLM ½ inch = 1 mile Color Quad Series
b. BLM ½ inch = 1 mile District Maps
c. BLM 1 inch = 1 mile Planning Unit Maps
d. USGS 15 min and 7½ min Quad maps

2. Availability - Currency, accuracy

Answer - Availability of map coverage by one or more of the series of maps listed in part A-1 is complete in all states except Nevada. Nevada has areas not covered by the newer series of maps. The areas are covered by the old Administratives Unit Maps.

Currency status of the series of maps used by the Bureau is questionable. It is estimated that at least 75% of the maps used are out of date by more than 5 years.

The accuracy standards of the series of maps produced by the Bureau will depend upon the methods used to make the maps. Where USGS quad maps were used as the base for the

Bureau map, the accuracy should meet the "Standard Mapping Accuracy Standards." Map identifiable objects will be shown within 1/50 of a inch at map scale of their true locations. Maps made by other than upon a USGS base will range from standard accuracy to very poor.

Source material recorders for Bureau map produced by the Denver Service Center are on file and accuracy standards for a given map can be obtained. The 30 minute quad maps produced by the Portland Service Center have a base map history index on them. The records for other maps produced in Portland have been lost.

Parts 3 and 4 furnished by Jerry Ives.

5. Volume

Answer - There are approximately 600 planning units in the BLM and each planning unit has the base map.

6. How long to get a complete, adequate base?

The USGS estimates that they will have complete coverage in the $7\frac{1}{2}$ or 15 minute quadrangle series by 1985. The 10 western states will be 50% covered by the new 1:100,000 map series by 1979. (100% by 1981).

B. Overlays - Special Maps or Other Supplements to Base Maps

1. Status - How many do we have; will have?

Answer - There are approximately 600 planning units in the Bureau. Approximately 75%, or 450 of the planning units do have the required Unit Resource Analysis (URA) overlays completed. An average URA will have 35 overlays, or about 21,000 overlays to be entered in to the Interactive Computer Graphic System.

The remaining (150) URA overlays will be finished within two years.

2. Condition - Completeness

Answer - The overlays studied are on mylar and in good physical condition. The overlays are registered to the base map in approximately position by hanger hooks. In areas of high activity the informaiton is in the process of being updated at all times. All the required overlays have been made for the URAs studied.

3. Can they be digitized or scanned?

   Answer - The overlays will have to be digitized by hand. Many overlays have more than one type of line information plus symbols, numerical and alphabitical data. The overlay data will have to be related to other maps by triangulation stations which are on the base map for some of the URA. The newer base maps use a coordinate system.

4. Which overlays should be entered into a system and which type should not.

   Answer - All phase II and phase III overlay information should be entered into the system. Phase II and III information is physical or policy data that effects decisions for making phase IV and V overlays.

   Considerations should be given as to entering data into the system from the original source data and not from the URA overlays. This data may be on USGS quad maps, maps from other agencies, computer print outs or in narrative form.

5. Accuracy

   Answer - The accuracy of line location on the URA overlays is dependent upon the type of information shown and the person drawing the line. Some types of information is of a general nature, such as wild life habitat area, and the line location accuracy is not required. Other types of information such as drainage areas, the line location can be specific, but may be place on the overlay in the general location only.

Lynn A. Strand

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DRAFT

C. Digitizing Graphic Data

1. Methods

a. Board and Cursor

(1) Off-line digitize, on-line edit

(2) Big computer vs. small computer

(3) Board position transducers

b. Raster Scan

(1) TV camera

(2) Drum scanner

(3) Microdensitometer

c. Line Follower

d. CRT and Point Controller

e. Key Entry

2. Board and Cursor

a. Board Sizes

b. Transducer Methods

(1) Strings, pulleys, shaft encoders

(2) Stervo driven worm/screws, shaft encoders

(3) Acoustic

(4) Track, linear optical encoders

c. Cursors

(1) Closed loop - contact maintenance

(2) Open loop - free-floating

3. Raster Scanners

3.1 TV Cameras

3.2 Drum Film Scanner

3.3 Scanning Microdensitometer

3.4 Software considerations

4. Line Followers

5. Interactive Graphics System

6. Costs

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7. Conclusions

8. Recommendations

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C. DIGITIZING GRAPHIC DATA

1. Methods.

Several methods of converting map and graph types of data into digital format have been used over the past 20 years as digital computers have come into widespread use. The motivation for digitization of map data is to have the high data processing rate digital computer to tackle the large amount of data that a map contains.

Processing of map data on digital computers is compatible from a resolution standpoint. Map data can have a moderately high spatial resolution with errors measured in a few thousandths of an inch over a span of a few tens of inches. The digital nature of data representation in computers permits virtually any degree of resolution. Thus, digital computers can readily accommodate any map data resolution.

Map digitization typically employs a mechanical measuring device with a conversion of the linear position measurement coordinates to electrical signals. The coordinates can be X and Y cartesian, rho and theta polar, or variations thereof such as line count (Y) and pixel position

(X). The electrical signals may be voltages whose amplitudes are proportional to the coordinates. In such case, these analog voltages are easily converted to digital format by an Analog-to-Digital (AD) Converter.

One widely used type of map digitization equipment is the board and cursor. Other types of digitizers are: the TV camera, the drum scanner, the computer controlled micro-densitometer, the computer-controlled laser beam, and the interactive graphics display. Each of these is discussed in detail below.

2. Board and Cursor.

The board and cursor type of digitizer has been available for many years. Modifications have been made as mechanical positioning measurement technologies were developed resulting in several different types of board/cursor arrangements.

a. <u>Beam Type Cursors</u>

Digitizing boards were initially modifications of plotting boards having a beam spanning the board surface and a cross hair fixture mounted on the beam. The beam is free to move in one direction (say X) and the crosshair fixture in the other direction, Y.

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The operator moves the crosshair fixture over the point to be digitized and presses a button to cause the coordinates to be digitized and recorded. The coordinate digitizer could be shaft encoders on a shaft common to pulleys over which run cables from the beam and the crosshair fixture for X and Y respectively.

Disadvantages of this early arrangement include obstruction of part of the operators field of view by the beam and the operator fatique caused by having to move the beam mass around.

One advantage of the beam cursor is that high resolution can be obtained by suitable shaft encoders.

An improvement on the beam type cursor is a board where the beam is cantilevered from a track running across the top of the board. The beam mount moves back and forth (to the operator's right and left) on the track. The beam moves in the mount perpendicular to the track axis for the second coordinate. At the end of the beam is mounted the crosshair in a fixture that contains sensitive strain detectors. When the operator moves the crosshair, the strain detector send signals to servo motors which move

the cantilever beam in the direction the operator desires. The servo-driven beam reduces operator fatigue. Since the beam is cantilevered from one edge of the board, less of the operator's field of view is obscured relative to a board spanning beam.

One cantilever beam type of digitizer is manufactured by Numonics. The digitizer can be mounted on any flat surface and does not require a special board. The position sensing is performed by light emitting diodes, photo sensitive transistors, and optical bar tracks mounted in the beam and on the beam track. The readout resolution is 0.01 inch over an area up to 2.4 inches by 36 inches.

b. <u>Free Cursor</u>

The free cursor is a small hand-held device connected by cable to the system electronics. The free cursor can be in the form of a holder contain a crosshair with up to a half-dozen push buttons, or can be in the form of a pen.

Applicon supplies a stylus type of free cursor with a data tablet. The data tablet is available in a

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range of sizes having working areas from 12 inches square to 34 by 44 inches. The resolution is specified as 160 lines per inch or 0.00625 inches. The stylus position sensing technique is not described in Applicon. Two stylus types are available: marking and non-marking. The marking stylus has a ball point pen tip. A manually operated switch is used by the operator to trigger the digitizing of the stylus position. The non-marking stylus has the switch incorporated which is closed when the point is depressed.

An example of a crosshair type of free cursor is supplied by Instronics in their Gradicon System and by Calma in their Calmagraphics system. The cursor contains a coil of wire that carries a current to generate a magnetic field. A sensor is mounted under the glass board surface on a beam and track. The sensor signal is fed to a servo-mechanism that detects when the sensor is not centered under the cursor crosshair, and drives the sensor mount to the center. The sensor mount position is readout via encoders coupled to the beam and track. (The sensor mount also supports a lamp which produces a halo of light under the cursor.) Accuracy of ± 0.003 inches is claimed for specially selected components.

Talos Systems offers a board using a free cursor that

can either the crosshair puck type or a pen stylus type. The sensing of the cursor is by means of a differential electronic servo system. Accuracies are a function of the cursor location. Optional accuracy of $\pm$ 0.005 inch is claimed with resolution of 0.001 inch while standard accuracy is $\pm$ 0.01 inch and standard resolution is 0.01 inch. Board sizes range from 11 by 11 inches to 44 by 60 inches.

Summagraphics offers a board with a crosshair type cursor or a pen-type stylus operating with a magnetostrictive sensing system. Boards are available with active areas ranging from 11 by 11 inches up to 36 by 40 inches. Resolution is 100 lines per inch for all board sizes with 200 lines per inch optional.

One pen-type cursor and board system is manufactured by Science Accessories Corporation and is called graf/pen. The graft/pen stylus emits a high frequency sound impluse which is detected by two linear microphone sensors which are mounted on two edges of the board. Since the sound waves travel through air, there is no need for the graf/pen stylus to be in contact or in close proximity to the board. Thus, any display surface such as a table, a drafting

board, a blackboard, or a projection screen can serve as a board. The microphone sensors can be supplied in any length up to 72 inches. A free cursor with crosshair is available and is plug interchangeable with the stylus.

Accuracy is specified to be 0.1% or 0.01 inch whichever is greater. The crossover point is at a board size of 10 inches square. For board sizes smaller than this, the accuracy is limited by the readout resolution of 0.01 inch. Larger boards have accuracies which decrease as board size (and microphone sensor lengths) increase.

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3. Raster Scanners

3.1 TV Cameras

Raster scanners can be adapted to automatic digitizing. One low cost raster scanner is the TV camera. Several companies offer TV cameras mounted on adjustable fixtures above horizontal light tables for viewing films and maps. Typical of such companies are Spatial Data Systems, Stanford Technology Corporation (International Imaging Systems subsidiary), and ISI of Lawrence, Kansas.

TV cameras have the disadvantage of low resolution relative to other raster scanners. Resolution varies from about 320 pixels by 240 lines to 640 pixels by 480 lines.

3.2 Drum Film Scanner

Optronics manufacturers a film digitizer that can be adapted to map digitizing if the map image is reduced in size to less than 10 inches on a side. The Optronics film digitizer has a drum on which the image transparency is mounted. A light source with optics is on the interior of the drum in a fixed position. A light

sensor is on the exterior of the drum also in a fixed position. The drum rotates to provide one of the scanning dimensions and is positioned along its axis of rotation by means of a lead screw to provide the second scanning dimension.

The optical system has several different square aperture sizes available measuring 25, 50 and 100 micrometers on a side. This small aperture provides a suitably high resolution for digitizing maps even after they have been reduced in size by a factor of 2 to 3 in linear dimension.

Associated with the Optronics scanner can be a magnetic tape drive for off-line digitizing or the scanner can be interfaced to a minicomputer for more integrated digitizing.

3.3 Scanning Microdensitometers

Microdensitometers used for measuring film densities have been adapted to automatic scanning by adding motor drives to the table. Tables are usually only large enough to accommodate the 9.5 inch square film image normally used in aerial photography; however, map images could be

photographically reduced to this size without much problem. The light source and sensor optics are very high quality and permit quite small apertures to be used.

Perkin Elmer has one such scanning microdensitometer available for sale or for contract use. One disadvantage of the microdensitometer approach to map digitizing is that the device is rather slow and represents overkill from a resolution standpoint.

3.4 Software Consideration

The scanner discussed above produce a stream of data that is very voluminous. A straight-forward scanner operating with a map having dark (or opaque) lines on a white (or transparent) background will produce one bit of information for each resolution element in the image. For the Optronics drum scanner, the number of resoltuion elements can be as high as 90 million for a single image. Most of the resulting 90 million bits of data will be redundant since they will represent the background. One method of reducing the number of bits is to use run length coding. Here, strings of

identical bits are replaced by a count of the number of identical bits in a sequence of identical bits.

In any event, the raw scanner data must be processed by a computer to transform the line by line scanner data to line segment or point data.

4. Line Followers

One firm, IO Metrics, has developed a system for digitizing graphic data using a laser beam line following technique. Use of this system is available on a contractual basis and the Geological Survey has had a large amount of data digitizied on the system. The system is called "Sweepnik" by IO Metrics.

IO Metrics has two laser beam line follower mechanisms controlled by minicomputers (DEC Model PDP 15s). The document containing the map must be a transparency through which the laser beam passes to a photomultiplier tube. The field over which the beam can be moved is limited in size to 160 mm by 110 mm (6.3 inch by 4.3 inch). For larger documents such as those being digitized by the USGS, GS overprints a grid forming rectangular cells measuring 120 mm by 80 mm. GS supplies to IO metrics two copies on transparent Mylar stable base plus one ozalid copy. IO Metrics cuts the two mylar copies into strips, each of which contains a rwo of grid cells with a large margin on either side. The strips are wound on a reel in the scanner housing. The operator manually positions each grid cell in the center of the operating area. The segment of film is held in position between two flat plates of glass.

A laser beam is used since it can be focused to a small spot. Spot diameter at the film plane is claimed to have 80% of its power in a 20 micron diameter circle. The beam is caused to nutate in a circular scan the diameter of which can be varied from 0 to 1.2 mm. Currently, the circle being used has a diameter of 1.0 mm. The circle is traced at 150 resolutions per second. The angular position around the circle is digitized to a resolution of one part in 4096 (i.e., 12 bits).

The operator manually positions the circular scan at an intersection point on the line using a trackball controller. Data fed to the computer from the laser scanner are:

a. The angular position where the beam intersects the <u>edge</u> of the line.
b. The angular width of the line.

The operator designates the direction the scanner is to follow the line. The scanner then automatically follows the line until it reaches an intersection. Intersections are determined by the line width exceeding a threshold value. The computer records the Table X, Y coordinates of the scanner at pre-scribed intervals along the line. GS specifies every 100

microns. Where the line contains sharp turns, data is recorded at smaller intervals to retain the line position information. Essentially, the line follower is automatic only from one intersection to the next. Operator intervention is required at every intersection to tell the scanner which direction to go for the next line. The data recorded on tape consists of these line segments running from intersection to intersection. The operator keeps track of which lines have been digitized by marking with a color pencil on the ozalid copy. The operator positions the beam with the aid of a TV monitor which displays the region around the scanning beam at 70x magnification. This display aids the operator in deciding where valid intersections are encountered or if the automatic line follower simply encountered a wide spot in the line.

Editing of the digitized map is performed with the aid of a Taktronix graphic display terminal. The editing operator looks for missing line segments and mismatches of lines that cross over the grid and hence are digitized at different times. The editor also codes areas on both sides of each line segment by typing code numbers in at the terminal keyboard. I cam away with the impression that there is a great deal of operator involvement in each stage of the map digitizing job using Sweepnik.

Problems encountered using Sweepnik on the GS maps were:

a. Line quality -- holes and gaps in the line, varying line widths.

b. Excessive density -- lines too close together.

IO Metrics uses college students on a part-time basis to operate the Sweepnik equipment. Operator shift length is limited to about four hours since the detailed visual demands of the job are tiring.

The Sweepnik is capable of generating a large amount of digital data along each line. As a result, curved lines appear to be well suited for line-follower type of digitizing. For straight lines, such as the cadastral grid, Sweepnik will generate a large volume of rdundant data. It takes only two points to define a line segment.

5. Interactive Graphics Systems

Several companies have developed interactive graphics systems (IGS) based on off-the-shelf hardware components and in-house developed graphics software. These systems are based on a minicomputer obtained from one of the prominent minicomputer manufacturers such as Digital Equipment Corporation, Hewlett Packard, Data General, Varian, etc. Also obtained from the minicomputer manufacturer will be those peripherals useful to the system usually including a single or dual platter disk memeory having 2.4 to 4.8 megabytes of storage capacity, a computer-compatible magnetic tape drive, and/or a communications interface. Once the data is digitized and edited on the IGS, it may be transferred to a large scale computer by means of the tape or over the phone line.

Other hardware components include a digitizer board with cursor and, almost always, a Tektronix storage CRT graphics terminal. The graphics display is an essential component in the editing step following digitizng. The graphics display permits the operator to view the data for omitted lines, erroneous locations of points, etc. Corrections are readily made to the digitized data residing in the IGS

in an interactive mode.

The interactive operating mode of the IGS is better suited to getting the digitizing job done correctly than is a batch mode computer with its long turn around delays between editing steps.

Representative IGS's are summarized below.

INTERACTIVE GRAPHICS SYSTEMS

1. Applicon, Intercorporated.

Graphic System 800 consists of PDP 11 minicomputer with 56k bytes of memory, 24 megabyte disk pak memory, 9 channel magnetic tape drive, Xynetics flatbed or Calcomp drum plotter, Tektronix graphic display.

Digitizer tablets have areas from 12 inch by 12 inch up to 34 inch by 44 inch.

Repeatability ± 0.003 inches

Accuracy ± 0.003 inches

Linearity ± 0.006 inches

Resolution 0.006 inches.

2. Auto Trol

Series 7000 Auto-Draft Interactive Graphics System:

Varian minicomputer, 48 kilobyte core memory.

Diablo disk memory with one fixed, one removable platter, 4.68 megabytes.

Tektronix 19 inch storage CRT graphics terminal

Teletype ASR33 console typewriter

Various plotters, drum and flatbed

Various digitizer boards:

a. Beam-mounted cursor using glass scale measuring technique, 50 by 60 inches.

   Accuracy $\pm$ 0.003 inch

   Resolution 0.001 inch

   Crosshair cursor with 3X magnifier.

b. Beam-mounted cursor using mechanical encoders, 35 by 57 inches working area.

   Accuracy $\pm$ 0.01 inch.

   Resolution 0.001 inch.

c. Free moving cursor, puck or pen type. Board size up to 36 by 48 inches.

   Accuracy $\pm$ 0.01 inch.

   Resolution 0.001 inch.

Software. Menu of geometric figures, operations user definable functions is interpreted from a board area. Menu can be placed anywhere on working surface of board.

Interface can be made to photogrammetric and other scientific equipment via rotary and linear encoders.

3. Bendix

Interactive Drafting System 100.

Datagrid digitizer board:

Active area 42 by 60 inches.

Resolution 0.002 inch.

Accuracy $\pm$ 0.005 inch.

Repeatability $\pm$ 0.002 inch.

Free cursor with 5 control button.s

ASR 33 Teletypewriter.

Floating keyboard (optional) with 28 or 51 alphanumeric, miscellaneous symbol and control keys.

Nova minicomputer, 24 k word memory.

Disk memory, one fixed, one removable platter, 5 megabyte capacity.

Magnetic tape drives (optional) 7 or 9 track.

Paper tape punch (optional)

Flat bed plotter (optional).

Tektronix storage CRT graphics terminal.

Fortran IV applications software Input/Output drivers written in assembly language.

4. Computer Equipment Company

Compugrid

Digitizer board dizes from 20 by 20 inches to 42 by 60 inches (this may be a Bendix Datagrid board).

Resolution 0.001 inch.

Accuracy ± 0.005 inch.

Free moving crosshair type cursor.

Floating keyboard, 52 characters.

Nova minicomputer, 32 kilobyte memory.

ASR 33 teletypewriter.

Optional peripherals: magnetic tape drives, RS 232 communication interface, punched card reader/punch, paper tape reader/punch.

5. Computervision Corporation

Interact II LIS

Digitizer board can also plot back 34 by 56 inch drawing surface.

Nova minicomputer with up to 128 kilobytes.

Magnetic tape, 7 or 9 track (optional).

Disk memory, up to 28 megabyte capacity.

Tektronix storage CRT graphics display incorporated in a design console.

Application software package CDP3/E for mapping, surveying, architectural, structural design, piping.

CVPL (Computervision Programming Language) allows user to program his own Fortran type input statements.

6. Gerber Scientific Instrument Company

Interactive Design System

Digitizer board is also a plotter.
Vacuum holddown.
Back lighting.
Four pen head.
Resolution: 0.001 inch.
Accuracy: ± 0.005 inch.
Repeatability: ± 0.003 inch.

Digitizer cursor is mounted on beam, servo driven in response to slight pressure by operator.

Tektronix storage CRT graphics display mounted in console.

HP 2100 minicomputer with 48 kilobyte memory.
Disk drive, 4.8 megabyte capacity.

Optional Equipment: Magnetic tape drives, additional disk drives, synchronous data set interface, hard copy unit for recording CRT

displays, plotters

7. Instronics

Gradicon System (as supplied to USGS Rocky Mountain Mapping Center).

LSI 11 microprocessor.

Digitizer board with working area of about 36 by 54 inches.

Free cursor.

Accuracy ± 0.003 inch.

ASR 33 with paper tape reader for program input.

Interface to 029 key punch for punched card output.

6. Costs.

a. Off-Line Digitizer Board System.

The digitizing system used by the BLM CRIS project consisting of a digitizer board and free cursor with controller feeding a magnetic tape drive, interactive editing of the data in the Cyber using a Tektronix storage CRT graphics terminal generated a cost figure of about $350 per township to digitize data for a set of 5 townships. Data digitized included the cadastral grid and ownership boundaries within sections, surface hydrology, the transportation net, and coal resource data. The resulting data file contained 338 kilobytes. The digitizing cost was approximately $1.00 per kilobyte.

b. Line Follower System (Sweepnik)

A cost formula has been developed by IO Metrics for Sweepnik usage and is:

$$\text{Cost (in \$)} = \{ 0.06 + 0.03 \sqrt{\text{No. of lines}} + 7 \times 10^{-7} \text{ (No. of Pts)} \} \text{ Area (sq. in.)}$$

Examples given were approximately $250 for a political boundary plate and $500 for a fairly detailed plate measuring 3 ft. by 4 ft. Two out of three example plates observed had predominantly curved lines. The Sweepnik system

appears to be well suited for curved line following since it can automatically follow the curves and record the very large volume of point coordinates necessary to define the line. For straight lines, Sweepnik will also produce a large volume of point coordinates, a large percentage of which will have little information content since only two points are required to define a straight line segment. Sweepnik appears to be at a disadvantage when such straight line segment information as the cadastral grid net is to be digitized.

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7. Conclusions

7.1 There is a wide variety of digitizing equipment available on the market, ranging from components such as boards, paper tape and magnetic tape data recorders, storage CRT graphic displays, minicomputers, disk memories, printers, keyboards, TV cameras, film scanners, microdensitometers, etc. to systems composed of these components together with software for geometrical manipulation and data film storage, editing and retrieval.

7.2 There is no system that automatically does the entire graphic digitizing job. This ideal system would consist of a hopper at one end which would accept BLM quad maps, USGS 7½ minute quads (1:24,000) and 1 degree by 30 minute (1:100,000) maps, planning unit overlays, Master title plats, survey plats, historical indices, etc. and a high data rate channel to a megascale digital computer having the BLM data base stored in its terabit random access store.

7.3 BLM graphic data is recorded on maps of differing scales, using a variety of line widths and a range of

quality. Data associated with graphics are available as alphanumeric characters, e.g., UTM, state plane, or latitude/longitude coordinates, area surface and sub-surface ownership categories. There is no one best system for digitizing this variety of input data forms.

7.4 A large amount of data awaits to be digitized in each of a variety of formats. Consideration should be given to using the best digitizing system for each class of data rather than attempting to use a single system for all classes of data. For instance, a key entry system appears well suited for gathering alpha-numeric data in existing BLM manual data files, a digitizing board appears suited for the digitizing of rectangular ownership lots and survey corners, and a line follower system appears well-suited for non-analytical curvilinear graphic data such as surface hydrography, soils maps, and resource overlays.

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8. Recommendation

Given that the digitization of the large amount of BLM map data is justified, it is recommended that several different techniques be employed where each type of data be digitized by the best technique available. For instance, where map location data is already in digital form on maps or plats, use key entry means to incorporate that data into the data base. Where the map data consists primarily of straight line segments, use a board and cursor to digitize only the end points of the line segments, and key enter the necessary ancillary data. Where the map data is curvilinear and extensive such as surface hydrology or soils, use line following equipment. A multiple of techniques is not wasteful since many digitizing units are required to handle the large amount of map data to be digitized. Thus, different types of equipment can be gainfully employed in the task withouthaving equipment idle.

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APPENDIX A

Map Series 1:100,000

The preparation of the 1:100,000 scale maps has been planned with future automated map scanning in mind. Multiple scribing plates for each color separation have been defined to limit each plate to one category of information. For instance, black plate 013 contains only the boundaries for national, state, county, civil and BLM district jurisdictions; while black plate 015 contains the land net (surveyed and protracted township, range and section lines, land grants larger than a section and section subdivision lines).

Difficulties for automatic scanning still remain in the 1:100,000 scale maps. For instance, where a road runs along a section line, the line on black plate 015 is deleted and the road line is scribed on one of the red road plats (021 or 022). In anticipation of this problem area, an intermediate film positive is made after the township, range and section lines are scribed. This plate, numbered 016 or 015A, will be satisfactory for automated scanning of the land net down to section lines but it does not contain any section subdivision lines. After the intermediate plate is produced, plate 015 is modified

to add the section subdivision lines and to delete any land net lines in conflict with roads and drainage (occasionally a canal or ditch may run on a section line). It, therefore, is not possible to automatically scan both the land net and section subdivision lines from the same plate.

Another problem exists in the section subdivision lines that run through the centers of sections 1, 6, 31 or 36 of any township. These four sections are labeled with their section numbers. This labeling requires that the subdivision lines be deleted where they conflict in the centers of these sections. (The section numbers are not offset from center to avoid the conflicts.)

DIGITIZING DEVICE CHARACTERISTICS

		IO Metrics Sweepnik	Optronics International Photomation P 1700	Spatial Data	Bendix Data Grid	Altek
Field of View	mm	160 * 110	230 * 230	254 * 254		
	inch	6.3 * 4.3	9.5 * 9.5	10 * 10	42 * 60	
Measurement	micron	1	25	∿500		
	mil	0.04	1	∿ 20	1	10
Pixels in Field of View		$17.6 * 10^9$ (160,000 by 110,000)	$90 * 10^6$ (9,500 by 9,500)	245,760 (480 by 512)	$2.5 * 10^6$ (42,000 by 60,000)	
Mechanism		Laser Beam Positioned by Mirrors	Drum On Leadscrew, Light Source Detector	TV Camera	Board Imbeded with Wires Cursor Sensor	Board Imbeded with Wires Cursor Sensor
BLM Digitizing Application		Hydrology, Contours	Hydrology, Contours	Overlays marked Felt Tipped Pen	Cadastral Grid, Point Data	Cadastral Grid, Point Data

USER ANALYSIS

1. Who and Where and How.

The predominant use of the interactive Graphics System will be made by the personnel at the District and Area offices. At this level Graphics will be mainly used to answer operational questions, prepare reports and to update the information that is stored. Computer Graphics will be very important in planning at this level, but in a different way than today. First the information will be more current, there will be more of it and it will be easier to access than at present. Secondly, planning will become part of a daily occurrence as information is put into storage, statistics recomputed, results studied and information evaluated possibly using techniques not readily available now. Instead of awaiting the hectic timing of AWP, periodic needs, pressures, local and national programs can be evaluated on a daily basis to determine the impact on Planning Units and Resource Areas.

Some use of the detailed information will be made at State level. Generally to check on severe problem, Planning or Social Pacing. At this level most of the data handling should be at an aggregate level but may still be displayed with background information, e.g., District features, etc.

DSC will have little use for the extremely detailed information except to sample and study. They will probably use graphics, but more as a reporting medium.

WO will also use graphics, but much in the same context as DSC.

2. What are they doing today?

There are many small differences in the way each District, Resource Area or Planning Unit, stores and displays information. The most typical operation when change occurs at the Planning Unit or Resource Area level, is to make a notation on a wall map or a map that may be in a filing cabinet identified to a specific resource. Then, as time permits, put the info on the proper overlay or do a more professional job on the wall map. Sometimes the info is put into folders marked by the Resource and Unit. These folders are then pulled out and researched when; a) questions are asked; b) AWP time; or c) if there is time to update.

Some of these systems are very effective in allowing access to information and in updating the current situation. This is because they were constructed following a specific needs guideline. Unfortunately there is very little standardization to these procedures and no way of aggregation.

When overlays are used, there is some reluctance to trust them unless the author or creator is the one using them. There is a large variation on how they are constructed and how accurate they are. Some

are meticulously drawn with a fine point pen while others are drawn with artistic sweeps of a felt tip marker. Probably each is adequate for the purpose in the Geographic Area they represent but it is impossible to combine data and get meaningful results.

3. Frequency of Requests and Data Volume

This is a very elusive area and the information is based on best guesses, for example, it is difficult to get "Number of Requests by Unit by Day" information. One extreme is to answer "All" questions with a Graphic System and the other end is to only use it at AWP or planning time. Probably the true answer lies closer to the "All" end than the other. It is hard for many to visualize what can be done and relate this to the day-to-day work. There seems to be generally two views:

1. I don't understand computers and don't see how they could help me in my job.
2. Star Trek - The Resource technician sets in a command chair with a giant screen in front of him. This screen has a detailed colored picture of the piece of world he wants to view and there are a matrix of buttons that solve all problems from "Best Fishing" to "Solution to Middle-East Oil Problem."

Again the median is somewhere in between.

The following table gives some guidance on volume.

DIGITIZING TIME AND VOLUME

Minimum Information

Minimum Data per Township

300,000 characters = 30,000 points

Base Map information	40 man hours
Minerals	40 "
Land Status	20 "
Ground cover/soils	40 "
	140 Hours per Township

Typical Planning Unit: 20,000 acres and 1,260 man hours
Characters by Typical Planning Unit: 3,375,000
Transmit Time (9600 BAUD): 60 min.

DATA REQUIREMENTS

Minimum Information

Minimum Data per Township

Descriptive

Source	Subject	# Characters
ORIS	Ground Cover/soils	115,000
CRIS	Minerals	130,000
Contract	Base Information	50,000
CRIS *	Land Status (Surface)	5,000
CRIS *	Land Status (Sub Surface)	5,000
		305,000

* Color quads not MTP
X, Y Point = 10 characters
Bureau total = 6.1 billion
Typical "window" - 7-1/2 min. quad.
Typical "window" - 450,000 characters
Transmit time (9600 BAUD) = 500 seconds
Transmit time = 8 minutes
Attribute data per township = 70,000

Souce:

Average Polygon = 40 Acres x 15 Characters x 576 (#40s in TWP) = 69,120
Transmit time: 1 min. 17 sec.

In the Strategic Plan page 5-139, Chart 4 (next page), some activity data was prepared. This corresponds very closely with the Team's estimates. We think, however, most of our estimates are very conservative.

The chart indicates there will be 5 billion characters activity per month. For a 20 working day month this reduces to about 250,000,000 characters per day. If this is further divided by approximately 70 districts it turns out that data transmission to each district would be about one hour per day. This sounds reasonable but again the estimate is probably low.

One could assume that a single "session" or inquiry at any point may eat up the hour and that would be it for the day. This may be true initially because it is assumed that the early tendency will be to ask for more data than can be used. This will soon reach a practical level just because of the time required to move data. When operators are experienced many questions will be answered by transmitting the answer only.

Data Sets	Average No./Period	Period	Distribution	Office	Total/Period	Average Trans Size	Char./Period
Vegetation:							
Forage	278	monthly	even	11	3,058	25K 200	76,450,000 611,600
Trees	278	monthly	even	11	3,058	25K 200	76,450,000 611,600
Soils	260	monthly	even	11	2,860	25K 200	71,500,000 572,000
Minerals	101	monthly	even	11	1,111	25K 200	27,775,000 222,200
Geologic	278	monthly	even	11	3,058	25K 200	76,450,000 611,600
Water	378	monthly	even	11	4,158	25K 200	103,950,000 831,600
Wildlife	278	monthly	even	11	3,058	25K 200	76,450,000 611,600
Meteorology	60	monthly	even	11	660	25K 200	16,500,000 132,000
Recreation	40	monthly	even	61	2,440	25K 200	61,000,000 488,000
Cultural	350	monthly	even	11	3,850	25K 200	96,250,000 770,000
Land Records	1700	monthly	even	11	18,700	200	3,740,000
Case File	1200	monthly	even	11	13,200	200	2,640,000
Socio-Econ	1700	monthly	even	11	18,700	200	3,740,000
A & FC	1800	monthly	even	11	19,800	200	3,960,000
Protection	278	monthly	even	11	3,058	200	611,600
M & O	300	monthly	even	80	24,000	200	4,800,000
Payroll	48	monthly	even	80	3,840	200	768,000
Property	20	monthly	even	80	1,600	200	380,000
Text	1700	monthly	even	80	18,700	200	3,740,000
URA	278	monthly	even	80	3,058	25K 200	76,450,000 611,600
MFP	1700	monthly	even	80	18,700	25K 200	4,675,000,000 3,740,000
Program Plan	5	yearly	=	80	400/12=33	200	6,600
Budget	4000	yearly	=	WO	4,000/12=333	200	66,600
OUTPUT					171,033		5,622,414,932
INPUT					21,510		168,907,450
TOTAL/MONTH					192,543 transactions		5,791,322,382 characters

Chart 4. Output

BLM GRAPHIC CAPABILITY

There are at present within the Bureau, four computer graphic systems designed to capture and manipulate geographic and natural resource information (AGIS, CRIS, ORIS, AND OASIS). Being largely independent efforts to meet localized user needs, these systems collectively provide a wide range of valuable software techniques that are not only the culmination of extensive development efforts but also represent the present state of the art in map graphics.

In consolidating the best software features from each of the four bureau systems the principal task will lie in the restructuring of the Input/Output formats into a set system structure and in interfacing to the Data Base Management System (DBMS) that will be resident on any large computer system.

Since each of the four systems was developed on a different computer system (AGIS on a Burroughs B2700, CRIS on a CDC CYBER-70, ORIS on an IBM 370-155 and a System 7, and OASIS on Computer Science Corporation's UNIVAC) the input - output formats especially in the area of random access were tailored to a specific machine's hardware and software requirements. Data structuring is the area in which individualization to meet set user needs is most prevalent.

The requirements of storing, organizing, and retrieving the vast amount of information necessary to make a Bureau-wide map graphics system viable will require the Data Base Management System be an integral part of the graphic system's structure and operation.

The consolidation of the bureaus graphic efforts is not only a viable source for a bureau graphic system but also represents the most cost effectiveness method to design a totally new system in-house. Contracting for this system would necessitate the redevelopment of techniques and methodologies already present within the bureau. This approach would also require training some personnel in Bureau mission and activities.

The definition of
Needed Geographic and Graphic Processing Capabilities Under the Strategic Plan for Information Systems

Bureau of Land Management
Interactive Graphics Study Team
December 10, 1976

A list of options for geographic and graphic processing capabilities, not yet a development charter or a set of deliverables, has been developed for review. User and management selection of capabilities for development, and verification of need, may be facilitated through a review of the options presented.

Specifications relating to speed, acceptability criteria, costs and development scheduling and method have not been sharply defined. Users are assummed to be primarily district and resource area people, some state office people and still fewer service center and Washington Office people. User skills in programming are assumed to be low or nonexistent. Use, in terms of user hours, is expected to be heavily oriented to field offices. Two figures and an option list for mapping and computer graphics capabilities under the Strategic Plan for Information Systems follow.

Technical readers should also refer to the "Minimum Technical Design Criteria" section.

FIGURE 1 - A review configuration for computerized, geographic (map) data handling and graphics capability options and relationship of mapping and graphics to other ADP capabilities under the Strategic Plan (numbers relate to review list of options).

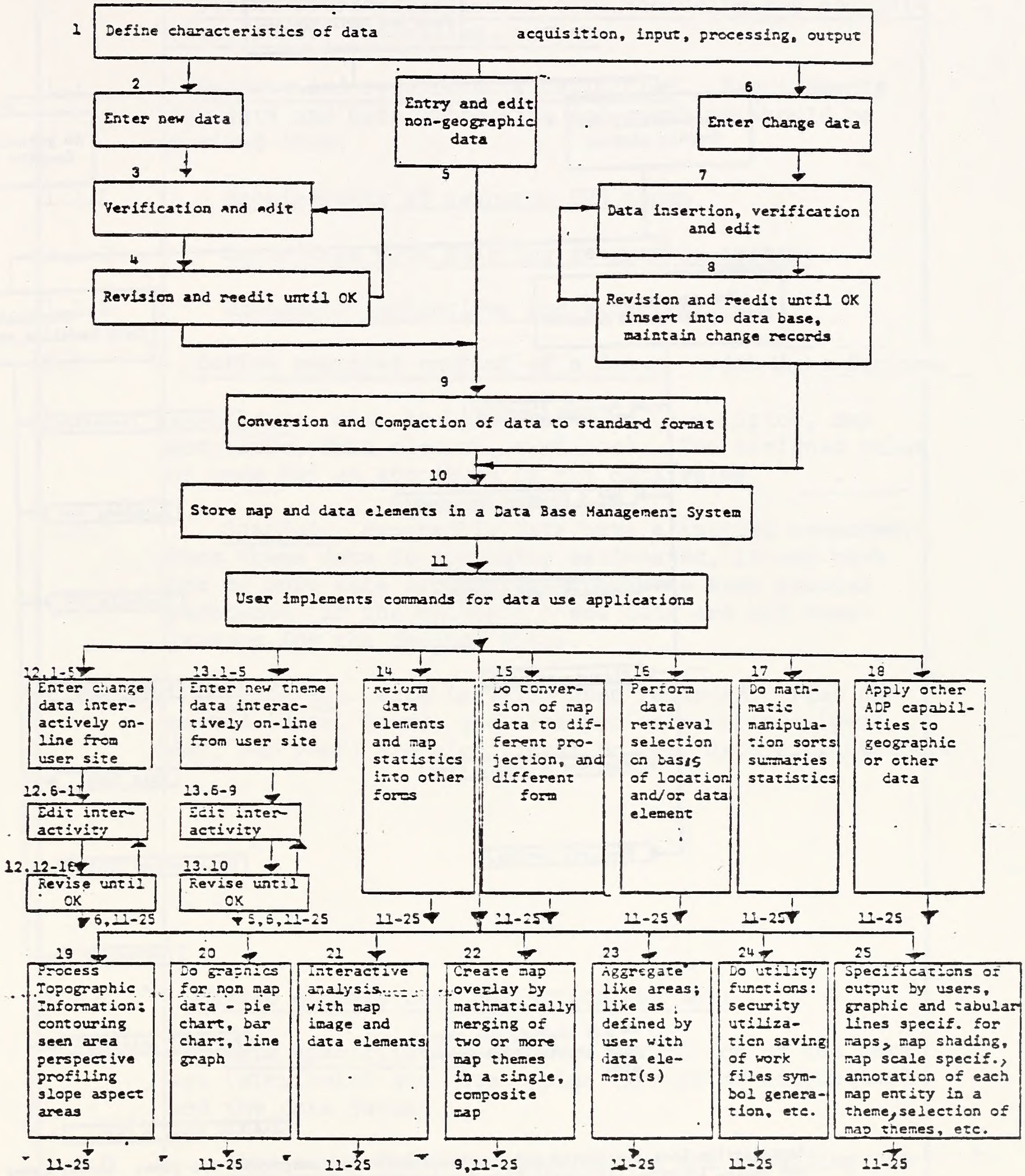
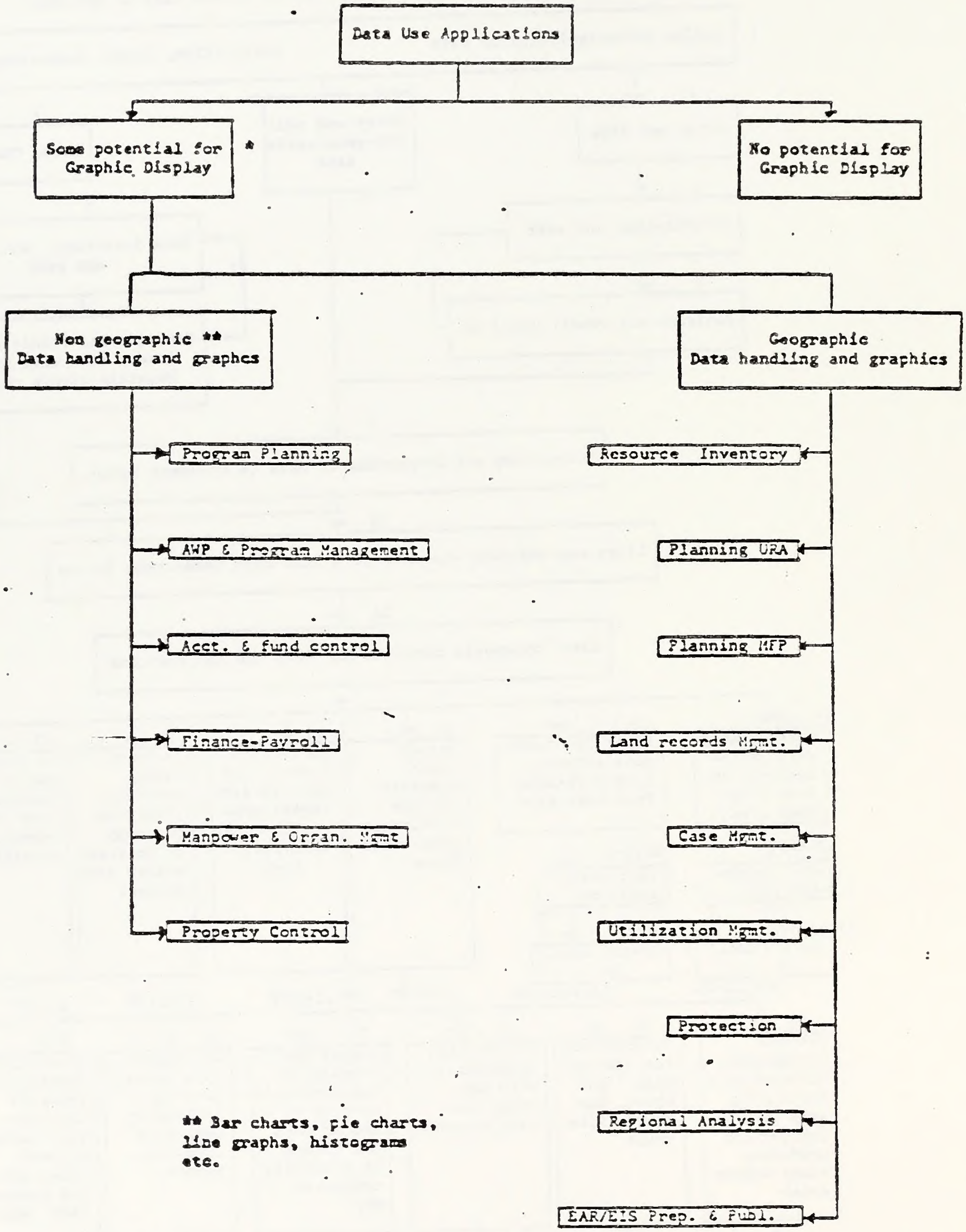


FIGURE 2 - Separation of graphic and nongraphic processing by application areas, graphics options consider all applications



*Application Packages listed under nongeographic and geographic are from: Linne, James M. and Smith, Susan D., Strategic Plan for Information Systems Management for the BLM Information Systems Steering Committee, Vol. 1, the Framework 1976, Fig. 2, p. 13.

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
1.	Define characteristics of data including map acquisition, input, processing, output
1.1	Do detailed requirements definition. Requirements for data and data processing and graphics should be derived from:
1.1.1	Requirements of resource DRD teams
1.1.2	Experience with existing geographic systems.
1.1.3	Management objectives and expectations.
1.2	Define required content of a datum: with three factors
1.2.1	Theme: what is being measured (descriptor, map attribute, data element, variable). The assigned value or code for an attribute is the data value.
1.2.2	Spatial: geographic data have a spatial component. When theme data is spatially delineated, it may have one or more data attributes within the same spatial reference if the multiple theme data are all homogeneous for the defined space.
1.2.3	Temporal: data is valid when recorded. Time observed (date, hour), and time period reference (per day, per year) are significant to many data applications.
1.3	Phases of data base collection and use:
1.3.1	Data specification involves definition of the data set (attribute) and data topics (groups of attributes) and the data format.
1.3.2	Data acquisition includes making and recording the observations.
1.3.3	Data storage, retrieval, and manipulation

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
1.3.4	Data dissemination is delivery of data to users.
1.3.5	Data applications are performed by users (man and/or machine) to carryout their operating-control-planning activities.
1.4	Spatial framework, collection units (points, lines, areas).
1.4.1	Point data can be:
1.4.1.1	Discrete distribution phenoma: such as wells, section corners, individual buildings, or
1.4.1.2	Continuous distribution data: recorded only at points such as rainfall, and temperature.
1.4.2	Line data can be:
1.4.2.1	Static: like roads, rivers, section lines, or
1.4.2.2	Dynamic: which covers movements and flows along lines.
1.4.3	Area data (eight irregular polygons or uniform cells in a grid) can be
1.4.3.1	Stock data: which are observations on data-elements which occupy areas such as vegetation, owner, etc.
1.4.3.2	Flow data: where spatial interactions between pairs of areas, e.g., ore mined in area X and refined in area Y.
1.5	Spatial area data collection units natural institutional and arbitrary should be guided by users need for data, and the ability and economics of data collection. Data and areas can be aggregated and generalized by users and machines, data cannot be disaggregated to smaller areas.
1.5.1	Natural units. A "natural" area/delineation and classification means that bounaries of areas are defined to coincide with discontinuities in the distribution of ~~the phenomena recorded. Areas based on stock data are~~

Number	Description
	uniform or physionomic regions, areas derived from flow data are called nodal or functional regions.
1.5.2	Institutional units. Administrative and political boundaries define institutional areas.
1.5.3	Arbitrary units. Arbritrary data collection units like satellite imagery cells or concentric rings about a point of interest may be used for data collection.
1.5.4	Areal resolution. Users needs, data sources and data applications and user region will be required as inputs to defining spatial resolution of data for different data themes (e.g. soils in Fairbanks and soils in Medford;and forestry in Flagstaff and forestry in Coeur d'Alene; forage in Duluth and forage in Winnemucca).

Number	Description
2.	Entry of new data for creation of an initial data base for a data theme (input)
2.0	Entry of new data. The information system must provide multiple methods of entering new data, most commonly from a manually useable form to a computer useable form. Differences in data and data source and number of data themes on source dictate the appropriate method for data capture efficiency and economy. This section focuses upon creation of the initial data bases and some batch processing is acceptable and expected.
2.1	Entry of geographic (map) data. Geographic referencing or coding of the location of map entities is geocoding. Methods of geocoding all data sources in Section 1 must be available in the information system to prepare graphic input. Geocoding of coordinates can be either direct (plane or terrestial) or indirect, map inches etc., and convertable to the standard coordinate system discussed in Section 9. Geocoding methods are part of the information system, but are prerequisites to the graphics system. Geocoding methods of preparing input to the geographic data base must include:
2.1.1	Manual digitizing of individual map entities (points, lines, areas) with line vectors between points on a line or perimeter. Geocoding options: - User selected points (x, y coordinates) - Continuous points (coordinates) taken on a distance moved or time elapsed.
2.1.2	Digital terrain model data taken at a grid of x, y positions regular or irregular and having some data element(s) recorded at each position, e.g. elevation.
2.1.3	Satellite imagery data processed into acceptable line or cell format must be storable and retrievable with the graphics system.
2.1.4	Raster scanning of a single theme map (and multiple theme maps with theme separation techniques). Scanned data for a single data theme must be separatable into map entities e.g. road segments and

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
	uniquely identified so that data elements entered separately can be related to the appropriate map entity. (Raster data converted to line data prior to input).
2.2	Entry of map attributes (data elements). Alpha numeric data descriptive of map entities is entered by one of the following:
2.2.1	Key entry to cards or magnetic tape or disk.
2.2.2	Optical character reader input of data.
2.2.3	Read in from an already computer readable source, e.g., satellite data.
2.3	Methods of associating data for individual map entities with its corresponding set of data elements must be provided for each data entry method.
2.4	Data formats must accomodate the input methods cited in 2.1 and 2.2 and data sources cited in Section 1 including point, line, area and cell and coordinate, bearing-distance and other data.

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
3.	Verification and edit of new data (error detection).
3.0	Data verification of new input data by both computer and manual methods is being required. Some data checking may be done concurrently and inactively at the time of data entry, other aspects may be best done by batch processing. Both map and data element edits are required to remove as many machine and/or manual errors as possible. This section focuses upon high volume work of creating the initial data bases.
3.1	Edit of geographic (map) data. Computer edit of map data is required to test for:
3.1.1	Complete coverage (area data only) no omissions.
3.1.2	Redundant coverage, identify multiple entry same entity.
3.1.3	Area closure
3.1.4	Line edit for underruns (e.g.), overruns (e.g.).
3.2	Edit of data elements. Computer edit of this descriptive map attribute data by data theme, and in some cases multiple themes.
3.2.1	Edit each attribute (data element) for valid codes
3.2.2	Edit for logical value/code relationships by applying cross attribute logic tests (e.g. an acceptable age-weight relationship and tolerance). Logical edit programs are application based rather than graphics based software.
3.3	Verification of map entity and map attribute linkage. Test for a complete match for each entity, no redundant matches.
3.4	Write out report of deviations from acceptable level for operator/user revision.
3.5	Visual inspection of map plotback and data listing

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
4.	Revision of new initial data after edit (error correction)
4.0	Revision of new data. Correction of invalid initial input data may be by computer or manual method (or both) and utilize both batch and interactive processes. This revision specifically designed to facilitate creation of initial data bases.
4.1	Computer only adjustment of data. Computer detection of erroneous, inconsistent, missing or redundant data to be followed by computer correction in cases where user judgement is not required. Output report of edit errors and actions taken.
4.1.1	Map registration, that is computerized fitting of an input map to existing data on the basis of user selected reference poings. This corrects map errors and distortion.
4.1.2	Map registration to standard reference coordinates system.
4.2	Manual "only" adjustment of data. Manual correction of computer or manually detected errors. Computer error findings should isolate problems and indicate their nature and if appropriate correction options. Manually redigitize, keypunch etc. the revision.
4.3	Interactive man-computer adjustment of data. On-line map and/or alpha-numeric data revision should be provided by the system, through a cathode-ray tube. Addition, deletion and changes of point, line, and area perimeter map data must be provided for high volume production operations.
4.4	Match map data & map attributed data. Apply Sections 4.2 or 4.3 to resolve multiple matches of data for a map entity, vice versa, or no match.

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
5.	Entry of nongeographic and/or other nongraphic data
5.1	Central computer site entry of data such as payroll, personnel, budget, timber cruise and appraisal data etc. Non-geographic, but processing by other ADP capabilities and possibly subject to graphic outputs such as bar charts, line graphs, etc. Subject to prior definition of format.
5.2	User site data entry of data same as above but input from a user terminal.

Number	Description
6.	<u>Entry of change (update/correction) data (input).</u>
6.0	<u>Entry of change data</u> to update or correct an existing data base should accomodate input from all sources cited in the section on entry of new (initial) data. All of the data input methods in the new data section should also be available for input of change data. This section applies to infrequent high volume update and revision of data which can be done in a delayed timing and away from the user site. Operator, but not user judgment, may be required. Batch processing is acceptable and expected for efficiency and economy.
6.1	<u>Entry of geographic (map) data.</u> Similar methods to section on new (initial) data entry (2.1, 2.1.1-2.1.4) with equal or greater accuracy plus: map entity addition, deletion, or partial change.
6.1.1	<u>Map registration points</u> in both the initial data base and the change data are required in the data. This is required for computerized fitting the change input map to existing data for the data theme (cited in data revision section).
6.1.2	<u>Computerized integration of change data into existing data.</u> Change data must be added to, deleted from or existing data modified by the computer.
6.1.2.1	<u>Insertion of revised line and area perimeter data</u> into the data base must be provided and fragments and remainders of lines (or areas) of the theme properly redefined and associated with their related data elements and revised map statistics (area, envelope length etc.) calculated. Include detection of resulting sliver areas and their disposition to either retention as an entity or merging into adjacent area. Coordinate with Section 8.6.
6.2	<u>Entry of map attribute change (data elements).</u> Entry of alpha/numeric data for the changed map entities and/or changed data for an unchanged map entity (points, lines or areas in a data theme) would be the same as described in Section 2.2.
6.2.1	<u>Addition and deletion of data elements</u> for all map entities, must be possible (will require coordination

Number	Description
	with data base manager.
6.3	<u>Methods of associating data</u> map and map attribute data must be provided when these data inputs are separated in time, location or technique of data entry.
6.4	<u>Data formats</u> must conform or be convertable to the existing data base.

Number	Description
7.	Data insertion, verification and edit of change data (error detection).
7.0	Data verification for change input data by both manual and computer methods is required. Some data checking may be done concurrently and interactively with data entry, other phases of editing may best be done by batch processing. Both map and map attribute data must be verified and edited. Infrequent high volume changes such as major reinventories are treated in this section rather than initial data base creation or daily file maintenance from the user site which is to be all interactive and on-line.
7.1	Edit of geographic (map) data. Computer edit of map data is required to test for:
7.1.1	Complete coverage and proper integration of revised line and area perimeter data. Small remainder lines and areas will have to be retained or merged with an adjacent map entity on user defined specifications.
7.1.2	Redundant coverage edit of lines, area perimeters, identify for removal (unless inconsistent with Section 9.1)
7.1.3	Area closure edit (,).
7.1.4	Line edit overrun, underrun (,).
7.1.5	Automate moving of a map entity to a new location specified by user: east, west, north, south, rotate.
7.2	Edit of data elements. Computer edit of this descriptive map attribute data by data theme, and in some cases multiple data themes.
7.2.1	Edit of each attribute for valid codes.
7.2.2	Edit for logical value/code relationships by applying cross attribute logic tests.

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
7.3	Verification of map entity-map attribute linkage test for a complete match of each and no missing or redundant matches.
7.4	Write out report of deviations from acceptable level for operator/user revision (for both map and map attributes)
7.5	Visual inpsection of map plotback and data listing.

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
8.	Revision of change data after edit (error correction)
8.0	Revision of change data. Correction of invalid change data may be by both batch and interactive processses.
8.1	Computer only adjustment of data. Same as 4.1
8.2	Manual "only" adjustment of data. Same as 4.2
8.3	Interactive man-computer adjustment of data. Same as 4.3.
8.4	Match map data and map attribute data. Apply sections 8.2 and 8.3 to resolve multiple matches of data for a map entity, vice versa, or no match.
8.5	Conversion and compaction of data to standard format.
8.6	Insertion of edited, change data into data base. Copy of corrected file reinserted into data base.
8.7	Maintenance of change record files. Maintain archival files of before, change, and after change. Include date, type of change (update or correction of map or attribute data, or both).

A REVIEW LIST OF OPTIONS, CRITERIA AND NOTES FOR GEOGRAPHIC (MAP) DATA HANDLING AND GRAPHICS CAPABILITIES OF A STANDARD BLM INFORMATION SYSTEM

Graphics Study Team, December 10, 1976

Number	Description
9.	Conversion of various input data to a standard format and data compaction (coordinate with Section 10)
9.1	Identify, format, convert and compact data to standard data format which will result in a minimum combined cost (considering: data storage, data processing, and data transmission) and a large scale to small scale map range which is large enough to introduce significant geodetic errors into a two dimensional map. Accept and convert all data sources cited.
9.2	Convert entered coordinated data from input device units digitizer, scanner cell, etc., into the standard geographic data base requirements. Convert all data themes to the standard to be used in the data base.
9.3	Use adequate precision in geodetic location coordinates to store data for large scale map use for some data themes.
9.4	Calculate the map statistics for geographic data files and each individual map entity in each theme, which are needed for graphics manipulations, e.g., envelopes, centroids, etc., and quasi "data elements" such as acreage, line length, etc.
9.5	Merge or otherwise relate map, map attribute data and map statistic data.

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Number	Description
10.	Store map and data elements: do geographic data base management and interface with data base management system (DBMS)
10.1	Partition the data base geographically and hierarchically for rapid and efficient retrieval of any data at any scale for any arbritrary area nationwide (where coverage is desired).
10.2	Define a local coordinate storage scheme for data themes within a geographic partition (see also and coordinate with 9.1).
10.3	Store for each partition as many separate data themes as required to define all single and multiple attribute data theme required by users for the partition.
10.4	Store frequently used data theme composites (see Section 22) of separate data themes with each partition.
10.5	Refine the data structure to interface with the DBMS to permit data retrieval by logical and relational associations of attributes within both a partition and an arbitrarily shaped area defined by a user which may span more than one partition.
10.6	Store work map files being created by a user or modified copies of the data base files being used in studies (such as alternative analyses).
10.7	Insure that the DBMS is properly instructed to update each of the pointer files (which relate data locations in the files) when authorized updates to coordinate data are received.
10.8	Protection of data base from accidental catastrophic damages by including sophisticated data base integrity checks and recovery.
10.9	Creation of copy of files for data protection when files are revised.
10.10	Security of files from open access for some confidential and sensitive information.

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Number	Description
10.11	Data base accessible from multiple locations and devices. Use time sharing techniques to allow sharing access to a data base through a communications network.

Number	Description
11.	<u>User implements commands for data use applications</u>
11.1	<u>Command control level</u>. A command interpreter should serve as a central control level for invoking system capabilities. The interpreter is software which is responsible for checking the command for valid syntax (format) and valid verbs. The interpreter would then invoke the system function associated with the verb, and also pass the related parameters to that function through a standard area (core and disk file). When errors are encountered, the interpreter should provide complete error diagnostics including corrective options.
11.2	<u>Error handling</u>. A discipline for error handling, diagnostic generation, control traceback, and break-point interrupt handling should be adopted across all system functions requiring these facilities. Under this dicipline, it should be possible for interrupt of a function at one level to be detected at levels above it.
11.3	<u>User access location</u>. Serve users who are resource specialists, clerks, line and staff people with available services from user sites; districts, state offices service center and headquarters. Users must not be required to have programming skills.
11.4	<u>Estimate of cost</u>. The kind of service desired and number and size of data base themes should be entered and formulas used for estimating cost and time to accomplish the service under different priority levels. User specification of priority and type of processing can then be done.
11.5	<u>Processing type and priority</u>. Cost and immediacy of of user need will influence user specification a processing method.
11.5.1	<u>Interactive on-line processing</u> of the data including manipulations in Sections 12-24 and output Section 25. This is appropriate for most small areas (Resource Area or Planning Unit) and/or simpler data sets over larger areas.
11.5.2	<u>Remote job entry of a job for off-line batch processing with interactive on-line set up of the processing</u>

Number	Description
	job(s). This is appropriate for complex map compositing, summaries, etc., requiring long processing times.
11.6	Alternative levels of user interface and system prompting response should be provided for infrequent users and frequent users.
11.6.1	Keyboard entered commands with English-like phrases.
11.6.1.1	Command syntax should follow a uniform format such as: (label) (verb) (positional parameters) (label) (verb) (keyword = parameters)
11.6.1.2	Saving of user-defined command sequences for subsequent use as procedures composed of system defined commands. (See Section 24.5)
11.6.1.3	Abort processing command to interrupt processing the previous command and return the system to a known status such as a return to the command monitor (to receive a new user command).
11.6.2	Command entry by selection of action from menu can be used when a few fixed options or functions are available. Menus may be slower than keyboard commands but they may give more prompting and guidance about options to users.
11.6.2.1	Used in lieu of keyboard command entry by users preferring menus.
11.6.2.2	Menu may appear on screen for use in choosing commands by using graphic crosshairs, typing a name (from a list), indicating choice with a graphic tablet cursor (electronic pointer), by number key, by pressure sensitive points on a tablet, light pen (electronic pointer) etc.
11.7	System request for user response should be uniform and include:
11.7.1	Audible sound signal used to indicate readiness for another command.

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Number	Description
11.7.2	Prompt symbol on the user device (CRT screen) such as a flashing light.

Number	Description
12.0-5	Entry of change (update/correction) data (input) interactively on-line and from user-site
12.0	Entry of change data to update or correct an existing data base should accomodate input data from user site devices (which should therefore have suitable resolution for map input). Change is done for only one data theme map at a time. Map and attribute changes are to be completed for a map entity under a computer prompt sequence leading the user through the process. Map changes should be shown on the CRT screen in refresh lines not fixed until acceptable edit has been achieved. Old and changed attributes (data elements) are to be listed&edited until OK.
12.1	Entry at geographic (map) data Similar methods to section on new (initial) data entry (2.1, 2.1.1) with equal or greater accuracy plus map entity addition, deletion, or partial change.
12.1.1	Map registration points in both the initial data base and the change data are required in the data. This is required for computerized fitting the change input map to existing data for the data theme (cited in data revision section).
12.1.2	Computerized integration of change data into existing data Change data must be added to, deleted from or existing data modified by the computer.
12.1.2.1	Insertion of revised line and area perimeter data into the data base must be provided and fragments and remainders of lines (or areas) of the theme properly redefined and associated with their related data elements and revised map statistics (area, envelope, length etc.) calculated. Include deletion of resulting sliver areas and their disposition to either retention as an entity or merging into an adjacent area.
12.2	Entry of map attribute change (data elements) Entry of alpha/numeric data for the changed map entities and/or changed data for an unchanged map entity (points, lines, or areas in a data theme) would be the same as described in section 2.2

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Number	Description
12.2.1	Addition and deletion of data elements for all map entities must be possible (will require coordination with database manager).
12.3	<u>Methods of associating data</u> Map and map attribute data must be provided when their data inputs are separated in time, location or technique of data entry. A cursor (cross hairs or other electronic pointer device could meet this requirement.)
12.4	<u>Data formats</u> must conform or be convertible to the existing data base.
12.5	<u>Visible highlighting of change data</u> both attribute and map changes until editing is complete.

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Number	Description
12.6-11	Insert data, do verification and edit of change data (error detection) interactively on-line and from user-site
12.6	Data verification for change input data by both manual and computer methods is required. Some data checking may be done concurrently and interactively with data entry, other phases of editing may best be done by batch processing. Both map and map attribute data must be verified and edited. Medium volume daily file maintenance from the user site, interactive and on-line, rather than infrequent, high volume changes are treated in this section.
12.7	Edit of geographic (map) data. Computer edit of map data is required to test for:
12.7.1	Complete coverage and proper integration of revised line and area perimeter data must be verified. Small remainder lines and areas will have to be retained or merged with an adjacent map entity on user defined specifications.
12.7.2	Redundant coverage edit of line, area perimeters, identify for removal (unless inconsistent with section 9.1)
12.7.3	Area closure edit
12.7.4	Line edit overrun, underrun (-+, -\)
12.7.5	Automatic moving of a map entity to a new location specified by the user: east, west, north, south, rotate.
12.8	Edit of data elements. Computer edit of this descriptive map attribute data by data theme, and in some cases multiple data themes.
12.8.1	Edit of each attribute for valid codes
12.8.2	Edit for logical value/code relationships by applying cross attribute logic tests (this is user application software).

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Number	Description
12.9	Verification of map entity-map attribute linkage: test for a complete match of each and no missing or redundant matches.
12.10	Write out report on CRT of deviations from acceptable level for operator/user revision for both map and map attributes)
12.11	Visual inspection of map CRT plotback and data listing.

Number	Description
12.12-16	Revision of change data after edit (error correction) interactively on-line and from user-site
12.12	Revision of change data. Correction of invalid change data may be by both batch and interactive processes.
12.12.1	Computer "only" adjustment of data. Same as 4.1.
12.12.2	Manual "only" adjustment of data. Same as 4.2.
12.12.3	Interactive man-computer adjustment of data. Same as 4.3.
12.13	Match map data and map attribute data. Apply sections 8.2 and 8.3 to resolve any multiple matches of data for a map entity, vice versa or no match.
12.14	Conversion and compaction of data to standard format.
12.15	Complete edit. Users will be required to:
12.15.1	Complete all map and/or attribute changes and edit until acceptable, or
12.15.2	Abort the change and accept the initial condition.
12.16	Maintenance of change record files. Maintain archival files of before, change and after change. Include data, type of change, (update or correction of map, or attribute data, or both)

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Number	Description
13.1-5	Enter new data for creation of an initial data base for a data theme (input) interactively on-line and from user-site
13.1	Entry of new data from user site interactively and on-line. Users must have the capability to create relatively simple new data themes from the user terminal using a map input device and source document of acceptance accuracy for the intended use. Similar to Section 2 but done from user-site. new data themes may be special study area boundaries, an evolving Management Framework Plan (MFP) areas, etc. Coordination with data base manager is required to obtain file space.
13.2	Registration of map to be entered to existing reference base map in the data base. Designate equivalent points to:
13.2.1	Register the map and provide the basis for computer fitting of the new map the stored map and
13.2.2	Correction of shrinkage or distortion in the input map, and
13.2.3	Basis for converting input coordinates to the standard coordinates of the data base.
13.3	Entry of the new map by manual digitizing at the user using a device like a graphic data tablet. New map entry displayed on a CRT as data is entered (over other themes).
13.4	Definition of map attributes, existing or new to be associated with the data theme being created. Coordinate this activity with data base manager to avoid redundancy and get space
13.5	Entry of attribute data for the new map. The data elements associated with the new map theme must be entered and associated with each map entity.

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Number	Description
13.6	Enter new data for creation of an initial data base for a data theme (input) interactively on-line and from user site, con't.
13.6	Verification and edit of new data by visual examination of the map image and data elements listed on a CRT and by computer methods.
13.6.1	Edit of geographic (map) data. Computer edit of map data is required to test for:
13.6.1.1	Complete coverage (area data only) no omissions
13.6.1.2	Redundant coverage, identify multiple entry same entity
13.6.1.3	Area closure
13.6.1.4	Line edit for overruns (e.g.,), underruns (e.g.,)
13.6.2	Edit of data elements. Computer edit of this descriptive map attribute data by data theme, and in some cases multiple themes.
13.6.2.1	Edit each attribute (data element) for valid codes
13.6.2.2	Edit for logical value/code relationships by applying cross attribute logic tests (e.g., an acceptable age-weight relationships and tolerance). Logical edit programs are application based rather than graphics.
13.7	Verification of map entity and map attribute linkage test for, a complete match for each entity, no redundant matches.
13.8	Write out report of deviations from acceptable level for operator/user revision
13.9	Visual inspection of map display and data listing.

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Number	Description
13.10	Revision of new initial data after edit (error correction)
13.10	Revision of new data. Correction of invalid initial input data may be by computer or manual method (or both) and utilize both batch and interactive processes. This revision specifically designed to facilitate creation of initial data bases.
13.10.1	Computer only adjustment of data. Computer detection of erroneous, inconsistent, missing or redundant data to be followed by computer correction in cases where user judgment is not required. Output report of edit errors and actions to user.
13.10.1.1	Map registration, that is computerized fitting of an input map to existing data on the basis of user selected reference points. This corrects map errors and distortion
13.10.1.2	Map registration to standard reference coordinate system
13.10.2	Manual "only" adjustment of data. Manual correction of computer or manually detected errors. Computer error findings should isolate problems and indicate their nature and if appropriate correction options. Manually redigitize, keypunch, etc., the revision.
13.10.3	Interactive man-computer adjustment of data. On-line map and/or alpha-numeric data revision should be provided by the system through a cathode-ray tube. Addition deletion and changes of point, line, area perimeter, and map data must be provided for high volume production operations.
13.10.4	Match map data and map attribute data. Apply sections 4.2 or 4.3 to resolve multiple matches of data for a map entity, vice versa or no match.

Number	Description
14.	Reformation of data variables: data elements attributes and data not related to maps) and map statistics
14.1	Variable reformation. The user must be able to specify data element manipulations necessary to put the data for each map entity into the best form for use in responding to his need. For example, if volume of wood on each mapped area is needed the user should be able to form and use a composite variable for area volume: Data element x map statistic to get new data element Wood volume per acre x Acres for area volume
14.2	Reformation methods. Arithmetic reformation methods must include addition, subtraction, division, multiplication, exponentiation, etc.

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Number	Description
15.	Do conversions of map data format and coordinates.
15.1	Purpose of map conversion. For high speed and/or lower cost map compositing or map display output in a different map projection (e.g., a Lambert Conic Conformal projection to a Universal Tranverse Mercator projection) it is required that the information system be capable of doing map conversion. The system would assume the standard case unless a user specified otherwise.
15.2	Map, form conversions
15.2.1	Area polygons to cells of user specifiable size (e.g., 1 mile by 1 mile, 1 meter by 1 meter, 10 ft by 10 ft).
15.2.2	Lines to cells containing part of the line.
15.2.3	Points to cell containing point, point count per cell.
15.2.4	Cell data to points, line and area data
15.3	Map projection conversions. To simplify and reduce cost of data storage map data would be stored in one standard projection such as Universal Transverse Mercator. Input data from other projections would be converted to the standard for storage and output maps requiring a different projection would be converted prior to drawing of the map.

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Number	Description
16.	Perform data retrieval, users at user-site terminal
16.1	Retrieval of locational data. Users must be able to specify retrieval and output map display or tabular lists of map entity data on the basis of a data element and/or geographic location parameters.
16.1.1	Retrieval on data element map statistic data bases. Use any combination of map attribute data elements, and/or map statistics or reformed data (see Sect. 14) to do this selective retrieval. For example: select and write or display only entities which are: color = green, age greater than, 35 and less than 46, etc.
16.1.2	Retrieval on locational relationships. Select on basis of points within an area, lines within an area, areas within an area. For example wells in a resource area, roads in a district, critical watershed in a township.
16.1.3	Retrieval on location basis, geographic window. Any arbitrary area may be used as a retrieval and/or display basis. Windowing capability options for defining an area for processing or map display follow:
16.1.3.1	Automatic scaling. Computer calculation of the scale which will just fit the area to be displayed on the paper or screen area available.
16.1.3.2	Window in is a command "zooms in" enlarging a user defined subarea on an existing display to a smaller area (results in a larger but unspecified map scale).
16.1.3.3	Window out is command which "zooms out" reducing the existing display area map scale and displaying a larger scale and displaying a larger area (results in a smaller but unspecified map scale).
16.1.3.4	Window with specified scale. A fixed map scale and point (e.g., center of desired display) may be used to designate a window area for display.

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Number	Description
16.1.3.5	Window to an area defined by named entities (e.g., townships) at the outer corners of a desired display (e.g., a set of 16 Master Title Plats)
16.1.3.6	Window to specified coordinates. Window to and do processing or display on the basis of user specified coordinates for corners of the area.
16.1.3.7	Window save. The user must be able to define and save any arbitrary area for future use in specifying processing or map display. For example an area containing a planning unit, study area, etc. might be specified.
16.1.3.8	Window to saved area. Users must be able to designate a saved area (see 16.1.3.7) during subsequent work.
16.1.3.9	Deletion of saved window. Saved named windows must be subject to user deletion when they are no longer needed.
16.1.4	Map entity selection. Users must be able to select an individual map entity (point line or area) from a data theme by a graphic pointer (movable crosshair or other electronic pointer). Once selected the user may switch from a map to a listing of data elements for the area, revise its shape, delete it, etc.
16.1.5	Proximity selection. Users should be able to retrieve entities within a user specified distance from points, or lines or areas having given characteristics.
16.1.6	Select on basis of edge characteristics. Retrieve data for processing or display on the basis of an edge characteristic (e.g., all areas bordering on elk wintering areas).

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Number	Description
16.2	Retrieve location. The user should be able to find out what area is displayed if use has been interrupted.
16.2.1	· Find and label the display of map or data listing with the area covered.
16.2.1.1	Window name
16.2.1.2	Coordinates for corners of the display
16.2.1.3	Township Range reference for whole map or map corners
16.2.1.4	Coordinates of a point indicated by the user with an electronic pointer.
16.2.2	Find and display coordinates of line intersection. Compute and display location of the intersection of two designated lines (in one or different data themes).

Number	Description
17	<u>Do mathematical manipulations</u>
17.1	<u>Arithmetic manipulation</u> Users must be able to specify arithmetic manipulations on data including reformation of data (section 14) and sorts, sort summaries, application of logical operations, limited statistical operations and formula application.
17.2	<u>Data sorting</u> The user must be able to specify criteria and do sorting into multilevel strata. Multiple sort levels (e.g. up to 9) need to be provided. For example, sort by District, planning unit, vegetation class, vegetation age, and slope.
17.3	<u>Data summation</u> The user must be able to summarize data in selected data elements and map statistics for all data in an area and by sorted levels. For example sort vegetation by resource area and age, class and sum acres by each age class (1, 10, 20 etc.) The user must <u>also</u> be able to specify the output, location and device (e.g. user site cathode-ray tube). Other examples: map entity counts, sums of data elements and sums of reformed variables.
17.4	<u>Apply logical operators</u> Users must be able to specify the application of logic to individual map entities for data retrieval and other manupilations. For example retrieve and display areas with no vegetation and which have slopes over 90 percent. Logical operators include AND, OR, NOT EQUAL, EQUAL, GREATER THAN, ETC.
17.5	<u>Limited statistical capabilities</u> Users should be able to apply simple statistical procedures to data without shifting to a full statistical capability program. Users should be able to sum data count entities calculate means calculate standard deviations
17.6	<u>Apply formulas including weighting functions</u> Do area calculations, grade calculations, distance calculations etc.

Number	Description
18	Apply other ADP capabilities
18.1	Other ADP capabilities Automatic data processing capabilities with geographic data include mapping, map compositing and other map data handling. Other ADP capabilities described under the Strategic Plan should also be accessible to the user from his location and provided with a self help guide to users. Text processing such as composition, update, and special processes such as time series analysis and simulation model processing should also be provided through the user-site terminal.
18.2	Access to nongraphic processing An effort will be made to make nongraphic processing available to user sites and non programmer users. Such processing would be set up so the computer prompted the user and guided his use of the computer.

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Number	Description
19	Process topographic information
19.1	Topographic data Topographic data storage may be in the form of contours or in positional coordinates with elevation data.
19.2	Do contouring The geographic-graphic system should convert data to required contour interval and display the data.
19.3	Calculate seen area The system should process terrain data to find the area which can be seen from a point, or a series of points along a line. For example: what area can be seen from points along a wild and scenic waterway.
19.4	Calculate slope aspect areas Calculate from terrain data (x, y coordinates and elevations) map area entity which have slopes within user defined intervals. For example: define areas which are homogeneous for slope percent classes such as:0, 1-5, 6-25, 26-55,56-76, 76+.
19.5	Calculate a profile along a line Develop a cross section profile between designated points. For example: a road profile, pipeline profile, cable logging profile etc.
19.6	Perspective view Calculate and prepare for output to paper or CRT a perspective view of a terrain model from a user specified location and elevation.
19.7	Surface presentation of data Display in perspective nontopographic data such as volume per acre, population density, traffic use (tons per mile per year) etc. as a third (elevation) axis. The third dimension could be used like elevation to show a surface.

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Number	Description
20	Do graphics for non-geographic data
20.1	Do nongeographic graphics: Calculate sums and proportions of geographic and nongeographic data.
20.2	Display nongeographic output Draw to user specified size.
20.2.1	Pie charts
20.2.2	Bar charts
20.2.3	Line graphs
20.2.4	Plot results of other ADP capability processing e.g. linear regression graphs

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Number	Description
21.	<u>Interactive user analysis of graphic image</u>
21.1	<u>User interaction with graphic image</u>. The user frequently needs to calculate and know limited measurements about a map so limited direct user analysis should be provided.
21.2	<u>User quantification</u>. Map statistic data should be available for each map entity in a data theme in the data base. Area and length measures should be available to the users for the superimposed themes in any cathode-ray tube map display. Other interactive changes should also be possible for cosmetic adjustment prior to copying or plotting.
21.2.1	<u>Area computation</u> using an electronic pointer to define an area in a CRT display.
21.2.2	<u>Perimeter and/or length computation</u> of a line or area or between two designated points.
21.2.3	<u>Label adjustment</u>, repositioning, so that annotation will not overlap other annotation.

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Number	Description
22.	Create composite map and map attribute data themes (overlay)
22.1	Data compositing. Data compositing in the merging of two or more data themes (map and attribute data) to create a new data theme. Separate maps mathematically combined to create the new map and a merged set of data elements associated with each of the new map entities. This process is sometimes called map overlay and it is like but more than the physical overlay of different themes. New map statistics are calculated for the map entities in the composite. Data theme composites of the following kinds are required.
22.1.1	Area and area, e.g., Soil and vegetation
22.1.2	Area and line patch, e.g., soil and road
22.1.3	Area and point, e.g., spotted owl nests and vegetation
22.1.4	Line and line, e.g., road and waterway
22.1.5	Line and point, uncommon, may not be necessary
22.1.6	Point and point, uncommon, may not be necessary
22.2	Apply logical operations. The user must be able to make inquiries on the composites using logical operations (Boolean algebra).
22.2.1	Intersection (I), e.g., soil P and vegetation S
22.2.2	Union (U), e.g., either soil P or vegetation S
22.2.3	Remainder (R), e.g., soil P but not vegetation S 
22.3	Apply logical operations to different composite types. Combinations of 22.1 and 22.2 should include the following:

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Number	Description

Operation	Composite Type: Area & Area	Area & Line	Area & Point
Intersection	P and S	P and S	P and S
Union	either P or S	Not applicable	Not applicable
Remainder	P & not S	P & not S	P and not S

22.4 Apply map composite procedures to data in a cell format. For approximations and economy data may be first converted to cell format (see section 15.2) prior to compositing.

22.5 Change data prior to composite. Prior to a composite operation it may be desirable to create a simplified data theme(s). Selective retrieval could be used to isolate the parts of the map and data applicable to the users problem. The purpose would be to make the results clearer, or reduce the time and cost for processing. (see section 16 on retrieval).

22.6 Set up by user. The user interface must provide for user specifications which tailor the composite to his needs. Interactive on-line, or setup from the users location for later off-line processing requires that the user specify:

22.6.1 Area to be composited (e.g., District x, planning unit y, window currently displayed on the cathode-ray tube, etc.)

22.6.2 Data themes to be composited (e.g., soils, lands, planning unit, selected vegetation).

22.6.3 Disposition of composited file. The user should designate the length of time that the file should be saved.

22.7 Do data file housekeeping.

22.7.1 Maintain file lists the system should enter the composite file name into data lists for subsequent use or user housecleaning elimination (coordinate with section 10 and data base.)

Number	Description
22.7.2	Calculate map statistics. Map statistics such as area length, etc. should be calculated for each map entity and these stored with the file. (coordinate with section 9 on data compaction).

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Number	Description
23.	Aggregate like areas as defined by users
23.1	Aggregate similar areas. The user should be able to define less complex maps by entering specifications for combining areas of similar characteristics. Two purposes are:
23.1.1	Scale reduction: A map with great detail and suitable at a large scale (1 inch = 1000 ft) may be needed at a smaller scale (such as 1/2 inch = 1 mile) for generalization of a data theme. If the map was originally stored with soil type and slope the user may wish to aggregate to only sets of many soil types and ignoring slope.
23.1.2	Data simplification: Generalized data may be needed even without a scale change (see 23.1.1 for example).
23.2	Disolve unnecessary lines: Internal lines in an aggregated area should not be drawn on a map output.

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Number	Description
24.	Do utility functions
24.1	Keep data secure
24.1.1	Limit access. The system should provide ways to limit who will have access or who will not have access to look at data (map and/or some or all attribute data). For example archeological data, personnel data and fiscal data may need to be wholy or partially restricted.
24.1.2	Limit data changing. Users may need to limit who is authorized to actually modify the data. For example users in Arizona should not change data in Wyoming and perhaps soil scientists should not change wildlife data without coordination with the wildlife man.
24.2	Save work copy of a file. The system should provide a user command to create a copy of a file and save it. For example an evolving action plan or an evolving revision of a Management Framework Plan needs to be saved and be separate from a current official file.
24.3	Keep a use record. The system should provide users with a record of use:
24.3.1	Who used it
24.3.2	What functions used
24.3.3	Data themes used
24.3.4	Data elements used
24.4	Help the user. The system should help the user by providing geographic and graphic data handling options (coordinate with section 11 and user assistance section 18).
24.4.1	Directory of capabilities
24.4.2	Directory of data themes
24.4.3	Directory of data elements

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Number	Description
24.4.4	Directory of geographic windows
24.4.5	Directory of map symbols
24.4.6	Etc.
24.5	Save a set of user commands. Users should be able to save a complex set of commands which have been generated to manipulate and/or display data. Reuse of a command set permits.
24.5.1	Easy generation of standard outputs such as maps or reports on a repetitive basis by:
24.5.2	User addition of current parameters such as: display area, date, map scale, data themes, etc. may need to be provided for in the saved command set.
24.6	Create symbols. Users should be able to interactively design and create symbols required for map annotation where these do not exist in a symbol file. These must be:
24.6.1	Entered
24.6.2	Edited
24.6.3	Revised
24.6.4	Designated for incorporation into map output
24.7	Create areas around points, lines, or areas. The system must be able to generate areas around points, lines or areas. Area creation is on the basis of:
24.7.1	Data element(s) having user specified values and/or
24.7.2	User specified map entities, designated individually with an electronic pointer while the entity is displayed on a CRT.
24.7.3	Purposes of area creation are to use the created area as part of a new data theme (e.g., creation of a buffer zone along a road or waterway in the development of a land use (MFP) plan. Map compositing of created areas

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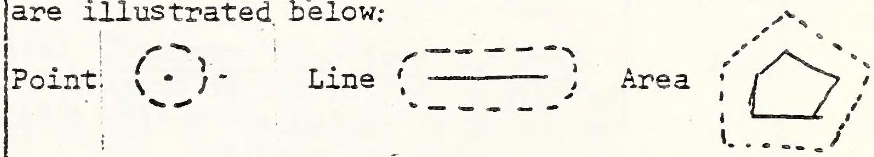
Number	Description
	would permit quantification (e.g., what and how much vegetation is in areas created around eagle nests).
24.7.4	. Sizing of created area would be controlled by user specifying width of area. Areas around map entities are illustrated below:



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Number	Description
25.	Specification of output by users
25.1	Put output on desired device. Users should be able to specify the output device. Available options need to include:
25.1.1	Cathode-ray tube (CRT) terminal screen at the user site
25.1.2	CRT paper copier (called a hard copy device)
25.1.3	Printer
25.1.4	Alpha-numeric terminal
25.1.5	Flatbed map plotter
25.1.6	File storage
25.1.7	Etc.
25.2	Default output. If the user does not define explicitly the device, scale, title or content the system should have a fallback assumption for output. e.g., CRT, automatic scaling window related to terminal location, etc. If insufficient information is given the system should make inquiries of the user.
25.3	Specify map output
25.3.1	Define map content. Users should be able to specify the data themes and apply selective criteria (data element, window, etc. see section 16). For example: the user may want a map of land status (all), roads (all) and forage (but only forage areas of a high production class).
25.3.2	Define map area. The user should be able to specify the map area and/or scale of output map. See section 16.1 for these retrieval capabilities.
25.3.3	Specify line types for drawing maps. The user should be able to customize the output map by picking line types (dashed, dotted, solid, etc.) while remaining within some standard line use pattern.

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Number	Description
25.3.3.1	Instruct system to draw an offset line. Display of a congruent boundary of an area(multiple boundaries along the same line) may require a slight offset to distinguish different lines as separate and distinct (e.g., master title plat line codes).
25.3.4	Specify map annotation (labeling). Users should have control of what annotation is put on each map entity displayed.
25.3.4.1	Specify map attribute(s) labeling, one or multiple, for each map entity to be put on the map (e.g., section number of the section area).
25.3.4.2	Specify map statistic labeling for the map (e.g., map acres for each soil area).
25.3.4.3	Specify map symbols for the output map. Users should be able to define map symbols to be used on a map. For example: put well symbols at each well location.
25.4.1	Define map output cosmetics. The user should be able to specify the map and have the system output on the map the following:
25.4.1.1	Title
25.4.1.2	User name
25.4.1.3	Data and time
25.4.1.4	Legend of line types and symbols
25.4.1.5	Location of title, legend, etc., on non CRT map output with interactive moving of these on a CRT preview of the plot, also interactive moving of annotations to a clear area if they overlap. (Up, down, left, right and rotate).
25.4.1.6	Scale of the map on CRT, paper copy of CRT, plotter, etc., include bar and numeric scale (e.g., either 1" = 1 mile or 1:63,360), include a bar scale.

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Number	Description
25.5	Instruction for shading or cross hatching map or graph. The user should be able to set two kinds of shading.
25.5.1	Fixed shading/hatching of areas (or along lines) having a user specified attribute (e.g., critical elk winterfeed).
25.5.2	Propertional shading or hatching according to class intervals defined by the user. For example: light if age 0-20, medium if age 21-80, dark if over age 80.
25.6	Set up graphs. The user must define graph output by
25.6.1	Picking data axis for data elements to be graphed
25.6.2	Selecting scaling units for each axis.
25.6.3	Labeling pie charts, bar graphs, etc.
25.6.4	Shading pie and bar charts
25.6.5	Draw graphs on CRT and/or plotter
25.7	Specify alpha-numeric output. Display alpha-numeric data element data as annotation on maps (see section 25.3.4). Also display lists of data elements for a given geographic entity.
25.7.1	Write data element lists. Display a list of data elements about a map entity in response to a users designation of the entity by name or electronic pointer. The user should be able to command
25.7.1.1	All attributes in a data theme, or
25.7.1.2	A user selected subset of attributes and
25.7.1.3	Specify the Output Device such as:
25.7.1.3.1	An adjacent monitor CRT screen which would not require erasing the main CRT map display.
25.7.1.3.2	An adjacent alpha-numeric (typewriter-like) terminal.

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Number	Description
25.7.1.3	3 The main CRT terminal by replacing the map display with the data list and subject to redisplay of the map).
25.7.1.3	4 By using a part of the CRT terminal screen for the data listing and retaining part of the map(perhaps all at a smaller scale).
25.7.2	Tabular data lists. Users must be able to set up tabular reports such as the sort and summary and statistical data (see section 17). The user must be able to specify columns, e.g., sort levels of selected data elements (if rows are individual map entities, and various summations of data elements, e.g., acres, number of areas, etc. Rows in the tabular report might be individual map entities, or whole strata levels of a summation.

Minimum Technical Design Criteria for a Mapping and Graphics Capability

Bureau of Land Management
Interactive Graphics Study Team
November 19, 1976

A minimum set of design criteria set forth in technical terms follows. These technical criteria are the fundamental basis for the capabilities set out in the list of options for geographic and graphics capabilities.

Number	Description
1.	User Interface Command Design
1.1	A command interpreter should serve as a central control level for invoking system functions. The interpreter would be responsible for checking the command for valid syntax and valid verbs. The interpreter would then invoke the system function associated with the verb, and also pass the related parameters to that function through a standard area (core or disk file). When errors are encountered, the interpreter should provide complete error diagnostics.
1.2	A discipline for error handling, diagnostic generation, control traceback, and breakpoint interrupt handling should be adopted across all system functions requiring these facilities. It should be possible under this discipline for interrupt of a function at one lever to be detected at the levels above it.
1.3	Keyboard entered commands
1.3.1	One unique key (such as "cntl C") should be defined as an interrupt or break to return the system to a known status such as a return to the command monitor.
1.3.2	Command syntax should follow a uniform format possibly of form: (lable) (verb) (positional parameters) (label) (verb) (keyword=parameters)
1.3.3	User-defined commands act as procedures composed of system-defined commands.
1.4	Menu entered commands
1.4.1	Used when there are a few fixed options or functions to choose from
1.4.2	Used in lieu of keyboard commands for users preferring menus
1.4.3	Menu may appear on screen for making a choice
1.4.3.1	by graphic crosshair
1.4.3.2	by typing a name
1.4.3.3	by using the tablet cursor

Number	Description
1.4.3.4	by number key
1.4.4	Menu may be positioned on tablet for choosing with tablet cursor
1.4.5	Cursor or crosshair picking may be by
1.4.5.1	pointing to the choice name
1.4.5.2	pointing to a box by the choice
1.5	System should signal request for user response with a signal uniform for all user inputs
1.5.1	audible signal
1.5.2	prompt signal on screen

MINIMUM TECHNICAL DESIGN CRITERIA

Number	Description
2.	Geographic Database Design, Management and DBMS Interface
2.1	Partition the data base
2.1.1	geographically and
2.1.2	hierarchically for retrieval of any data at any scale for any arbitrary area nationwide.
2.2	Define a local coordinate storage scheme for themes within a partition
2.3	Convert input themes from digitizer (input coordinates) to geographic and database coordinates; intersect input themes with partitions for storage
2.4	Store for each partition as many separate themes (overlays) as are required to define all single and multiple attribute thematic (polygon, choropleth) maps for the partition.
2.5	Store for each partition the composites of separate themes which are frequently recalculated
2.6	Examine data within partitions by individual themes input from separate source maps covering adjacent areas in each partition to preclude cospatial encoding of a single theme (tautological overlay)
2.7	Further refine the data structure to interface with the DBMS to permit
2.7.1	Data retrieval by
2.7.1.1	logical and
2.7.1.2	relational associations of attributes
2.7.2	within both
2.7.2.1	a partition and
2.7.2.2	an arbitrarily shaped user defined area which may span more than one partition.
2.8	Provide thinned (weeded) data for these retrievals; merge partitions for these retrievals; provide generalized data for these retrievals when display is requested at smaller scale for larger areas

Number	Description
2.9	Insure that the DBMS is properly instructed to update each of the pointer files used for retrieval when updates to <u>coordinate</u> data are received from authorized terminals

MINIMUM TECHNICAL DESIGN CRITERIA

Number	Description
3.	Database Creation
3.1	Data formats
3.1.1	Conventional maps
3.1.1.1	Arc, polygon, point
3.1.1.2	cellular format
3.1.2	Tabular attribute information
3.1.3	Other
3.1.3.1	Bearing distance
3.1.3.2	Field surveys and inventories
3.2	Data verification and topologic edits
3.2.1	Computer verification of polygon closure
3.2.2	Computer verification or assignment of polygon attribute linkage - node adjustment
3.2.3	Computer verification through area cross checks of map completeness
3.2.4	Computer verification of data consistency (internal)
3.2.5	Interactive editing of text information
3.2.6	Interactive a editing of arc, polygon, point
3.2.6.1	Delete an arc
3.2.6.2	Add an arc
3.2.6.3	Delete a point
3.2.6.4	Add a point
3.2.6.5	Move a point
3.2.6.6	etc.
3.2.7	Map registration (computerized fit of map input to existing base map.)

MINIMUM TECHNICAL DESIGN CRITERIA

Number	Description
3.2.7.1	Standard reference systems (accepted - converted to std for storage) Latitude/longitude State plane coordinates Universal Transverse Mercator, etc.
3.2.7.2	User selected reference points for adjustment
3.2.7.3	Map distortion (adjustment by computer paper stretch, etc.)

Number	Description
4.	Database Update. Function same as data base creation; repeat numbering beginning with 4 instead of 3.

MiNiMUM TECHNICAL DESIGN CRITERIA

Number	Description
5.	Manipulation/Analysis/Utilities
5.1	Locational retrievals
5.1.1	point in polygon
5.1.2	polygons within a user defined window (polygon) (retrieval area)
5.1.3	cursor selection of a line or point feature
5.1.4	proximity selection (everything within a given distance of a point, line or polygon)
5.1.5	select on edge characteristics (all areas bordering urban development)
5.2	Overlays (utilizing all boolean operations)
5.2.1	polygon overlay with area, length perimeter calcs
5.2.2	cellular overlay with area, length perimeter calcs
5.3	Reclassification of variables reformation and combination of variables to be new attribute new code for an attribute
5.4	Mathematical aggregation of variables
5.4.1	summation
5.4.2	statistics
5.4.3	formulas, including weighting functions
5.5	Conversion of cellular data to polygon
5.6	Conversion of polygons to cells
5.7	Conversion from std map projection to another projection for display
5.8	Interactive design and creation of symbols/symbol sets
5.9	User interaction with the graphic image
5.9.1	area computation

MINIMUM TECHNICAL DESIGN CRITERIA

Number	Description
5.9.2	perimeter/length computation
5.9.3	label adjustment
5.10	Shading/crosshatching

Number	Description
6.	Graphic and Alpha Display (output) and input.
6.1	Be able to obtain current location of graphic beam
6.1.1	in absolute screen coordinates
6.1.2	in verbal screen coordinates
6.2	Be able to move graphic beam to a given location
6.2.1	Direct move
6.2.1.1	absolute coordinates
6.2.1.2	virtual coordinates
6.2.2	Relative move
6.2.1.1	absolute increment
6.2.1.2	virtual increment
6.3	Be able to draw from current graphic beam location to another location
6.3.1	Direct draw
6.3.1.1	absolute coordinates
6.3.1.2	virtual coordinates
6.3.2	Relative draw
6.3.2.1	absolute increment
6.3.2.2	virtual increment
6.4	Be able to set bounds of screen window
6.4.1	absolute coordinates
6.4.2	virtual coordinates
6.5	Must have several distince line types for drawing vectors
6.6	Be able to obtain location of a graphic crosshair on screen

Number	Description
6.6.1	absolute coordinates
6.6.2	virtual coordinates
6.7	Graphic tablet support
6.7.1	obtain absolute coordinates of tablet pen or cursor when pressed
6.8	Character and symbol output
6.8.1	Hardware characters
6.8.1.1	Full ASCII character set
6.8.1.2	multiple sizes
6.8.1.3	output horizontally from current alpha cursor position
6.8.1.4	line-full and page-full handling
6.8.2	Software character/symbol
6.8.2.1	generation from symbol definition table
6.8.2.2	scalable based on virtual window
6.8.2.3	slantable
6.8.2.4	rotatable
6.8.3	Move alpha cursor position to a location
6.9	Character input
6.9.1	full ASCII keyboard
6.9.2	obtain position of alpha cursor

GLOSSARY OF TERMS

1. BATCH PROCESSING
A method whereby items are coded and collected into groups and then processed sequentially.

2. BAUD
For practical purposes it is now used interchangeably with "bits per second" as a unit of measure of data flow, i.e., 9600 Baud equals about 900 characters per second.

3. BYTE
Group of consecutive binary digits operated upon as a unit and usually shorter than a computer word (e.g. a 6-bit or 8-bit byte).

4. CELL
The smallest region in a grid.

5. CHOROPLETH MAP
Map showing discrete areas such as states or counties. These units are considered uniform with respect to the statistics collected within them.

6. CONGRUENCING
The digital transformation of images so that their geometric properties can be related.

7. CONTOUR
Line joining points of equal vertical distance above or below a datum.

8. CRT
An electronic vacuum tube containing a screen on which information may be stored by means of a multigrid modulated beam of electrons from the thermionic emitter storage effected by means of charged or uncharged spots.

9. CURSOR
Aiming device, such as a lens with crosshairs, on a digitizer.

10. DATA BANK
An information store usually in digital form organized in such a manner that retrieval and updating can be done on a selective basis and in an efficient manner.

11. DATA BASE MANAGEMENT
A systematic approach to storing, updating and retrieval of information stored as data items, usually in the form of records in a file, where many users, or even many remote installations will use common data banks.

12. DATA ELEMENT
Discrete defined information variables are known as Data Elemen. Map atribute Data Elements which describe a map entity are known as map attributes.

13. DATA TABLET
A flat tablet which will output the digital position of a pointer placed at any position on its surface.

14. DATA THEME
A user delineated data category consisting of a map and map attribute(s) will be known as a data theme. A theme will contain only one type of map entity (points or line paths, or areas).

15. DENSITOMETER
Device used to measure the density of a small area on a film. Density measurement is calibrated against a standard opaqueness.

16. DIGITAL IMAGE
A two-dimensional matrix which represents an area on a photograph. Each position of the array is assigned a grey level, which may be limited to two. Synonym: Digitized Image, Digital Picture Function.

17. DIGITIZER
A device that converts an analog measurement into digital form.

18. DIGITIZATION, MANUAL
The process of conversion of analogue or graphic data into digital form by an operator with or without mechanical or computer aids.

19. DIGITIZER, GRAPHIC
Machine that changes graphic cartographic information into a digital format for computer input.

20. DIGITIZER, LINE-FOLLOWING
Device which automatically tracks an individual line and at selected intervals digitally records its position with respect to an arbitrary coordinate system.
Synonym: Automatic Line-Following, A.L.F.

21. DIGITIZER, POINT
A manually controlled cursor senses position, usually by electromechanical means. An operator must activate the recording of positional elements or other information.

22. DISPLAY
Any graphic presentation in hard-copy or as a transient image or A device (usually CRT) attached to a computer for the rapid dis of selectable information in map or list form.

23. DISPLAY, ALPHANUMERIC
A display system usually CRT, which produces lists, texts, or spaced alphanumerics on a screen, the alphanumeric shapes being produced wither by hardware or software generators.

24. DISPLAY, INTERACTIVE
Display with a facility for an operator to modify the data by designating locations.

25. DISPLAY, LINE DRAWING
A display system (usually CRT) which produces an image from lines drawn as a series of dots or vectors on a screen.

26. EDGE
Exact term for the division between two mapped areas which is exterior to the subset being bounded.
Synonym: Boundary.

27. EDITING
Detection and correction of the data obtained in graphic data reduction.

28. FEATURE
A cartographic type e.g. coastline. or
A cartographic type in digital form appearing as part of the descriptor in coded form (Feature Code)

29. FIRMWARE
Logic circuits in read-only memory that may be achieved by the software under certain circumstances.

30. GEODETIC COORDINATES
Latitude and longitude with reference to a standard spheroid.

31. GRAPHIC
Symbol produced by hand or machine drawing, or by printing. or
Completed map or chart produced as in the above definition.

32. GRAPHIC FORM
A physical or pictorial representation of data such as printing plotting output or CRT drawings.

33. GRID COORDINATES
Euclidean coordinate system in which points are described by perpendicular distances from an arbitrary origin.

34. HARD-COPY
Any map, chart or graphic presentation recorded on a sheet in such a manner that it may be stored or transported.
Synonym: Descriptor, Identifier, Label.

35. HARDWARE
The mechanical, magnetic, electrical and electronic devices or components of a computer.

36. HEURISTIC
Helping to discover, learn, or to inspire inventigation. An unstructured approach to problem solving.

37. HILL SHADING
Shading employed to create a three-dimensional impression of relief.

38. INTERACTIVE
Man-machine conversational interaction with the user giving an instruction and the computer doing the task and responding. Response ration is less than 100.

39. INTERACTIVE POSITIONING DEVICE
A device which is operated manually to locate a specified position, usually on a CRT display screen. The location will be identified on the screen and will be recorded by the computer. Devices used may be a tablet, joystick, 'mouse', tracking ball, or lightpen. See also Data Tablet.

40. INTERSECTION
Region containing all the points common to two other regions.

41. ISLAND
Single-line boundary within a polygon.

42. JOIN
The process of joining 2 pieces of data in digital form when joining may require interpolation or clipping of data points. If the join situation is not exact and has to be modified requiring data erasure with interpolation, the operation is then usually referred to as merge.

43. JOYSTICK
A small control lever which can be moved in any angular direction. It may output an analog or digital value proportional to position or a value proportional to direction but with a rate signal dependent on deflection. In the former case the joystick will remain at any set position, but in the latter automatically returns to center.
or
See Interactive Positioning Device.

44. LABEL
Descriptor of an item being digitized.

45. LETTERING (CARTOGRAPHIC)
All names, letters and figures appearing on the face of a map.

46. LIGHT PEN
It is a high speed, photosensitive device with which the "operator" can cause the computer to change or modify the display on the cathoderay tube.

47. LINE CLOSING
Making two lines, or the two ends of one line, to have a common node.
Synonym: Line Joining, Line Merging.

48. MAP, BASE DETAIL
Map used as a primary source for compilation or as a framework on which new detail is printed.

49. MAP ENTITY
Each separately identified geographic entity can have different descriptive attributes associated with it. Three types of geographic (map) entities will be recognized; points line paths, and areas. Map entities are delineated by applying user defined criteria and the resultant entities are assumed to be homogeneous within some standard.

50. MAP, PLANIMETRIC
Map showing only the horizontal location of detail.

51. MAP, THEMATIC
Map designed to demonstrate particular features or concepts. In conventional use this term excludes topographic maps.

52. MAP, TOPOGRAPHIC
Map whose principal purpose is to portray and identify the features of the earth's surface as faithfully as possible within the limitations imposed by scale.

53. MICRON
A unit of length equal to one thousandth of a millimeter, i.e., one millionth of a meter or 39 millionths of an inch.

54. MINICOMPUTER
A low cost computer with limited core capacity. Widely used for device and system control and data handling when large computations are not involved.

55. ON-LINE
Discriptive of a system and peripheral equipment or devices in a system in which the operation of such equipment is under control of the central processor.

56. ORTHOPHOTOGRAPH
Copy of a perspective photograph from which distortion due to tilt and relief have been removed.

57. OVERLAY
Map of an area to be superimposed on one or more maps of the same area. The purpose is to find data combinations, or more exactly intersections and unions.
or
Digital image of areas as in definition one above.

58. POLYGON
Plan figure consisting of three or more vertices (points) connected by line segments or sides. The plane region bounded by the sides of the polygon is the interior of the polygon.

59. RASTER SCAN
A line-by-line sweep across a display surface to generate or record an image.

60. REAL-TIME PROCESSING
Processing which appears instantaneous to the person or device controlling a computation.

61. REGISTERING
The alignment process by which two or more map or chart overlay sheets are made coincident for color printing purposes.

62. RELIEF REPRESENTATION
Any technique used to depict the configuration of the surface of the earth (or other heavenly body) on a map, e.g. contouring, hill shading, layer tinting.

63. RESOLUTION
Measure of the ability of an imaging system to separate the images of closely adjacent objects. The units might be, cycles or lines per mm., least separation in mm., least separation in radians.

64. RESPONSE RATIO
Ratio of elapsed time to computer processor execution time. Batch, interactive and real-time systems (and processing) differ primarily with respect to response ratio.

65. RESPONCE RATIO - BATCH
The response ratio is large, typically being over 100. Complex procedures such as a sort-summary for a whole planning unit could use this slower mode.

66. RESPONCE RATION - REAL-TIME
The response ratio for this processing is less than 5. The BLM Strategic Plan will probably not require real-time processing.

67. SCANNER
Any device which systematically breaks up an image into picture elements (or pixels) and records some attribute of each picture element. .

68. SEGMENT
Subset of consecutive polygon points.
Synonym: Link, Arc.

69. SMOOTHING
Filling a line of observed data points by a continuous line.

70. SOFTWARE
The internal programs or routines professionally prepared to direct a computer in its operation.

71. TELEPROCESSING
A term denoting systems that transmit data from one point to another in the course of processing.

72. THINNING
Removal of redundant points composing a line, in order to reduce storage requirements.
Synonym: Culling.

73. UNION
Region containing all of the points in either of two other regions.

74. WINDOWING
A method of designating and separating out a particular area of map data for presentation on a display.